GAZPROM

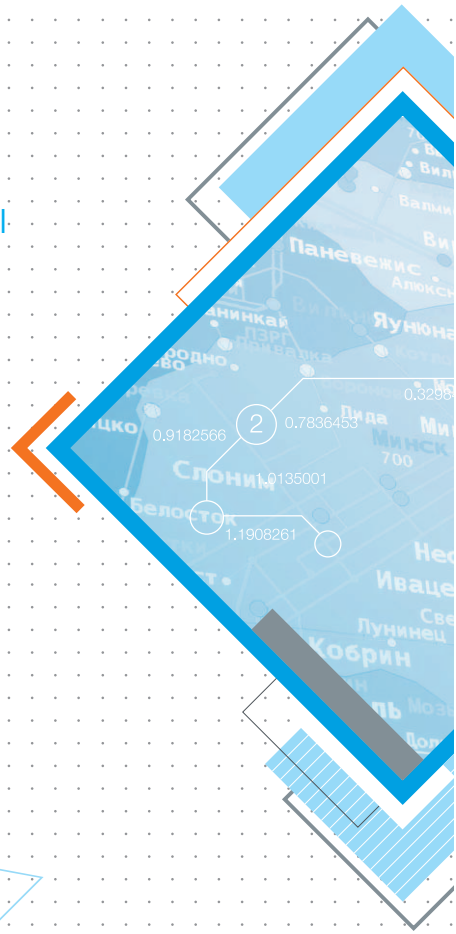
2021 YEAR OF SCIENCE AND TECHNOLOGY

GUBKIN UNIVERSITY

DISCOM 2021

VII International Science and Technical Conference

# COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS




October 14–15, 2021

Moscow, Gazprom VNIIGAZ LLC

GAZPROM VNIIGAZ

GAZPROM

VII International Science and Technical Conference

# COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

October 14–15, 2021

Head of Department,
Gazprom PJSC
**C.N. PANKRATOV**

**Dear colleagues!**

On behalf of the management of Gazprom Public Joint Stock Company and on my own behalf, I welcome the participants of the VII International Scientific and Technical Conference DISCOM-2021!

DISCOM conferences have been held since 2002? and their holding has already become traditional. I am glad to see both our familiar colleagues and new participants among the participants of the conference. This is probably the only gas conference in Europe that unites specialists in the operation and development of automated dispatch control systems. This year the conference coincides with the Year of Science and Technology in Russia, as well as the 60$^{th}$ anniversary of the dispatching control of the Unified Gas Supply System.

The entire process of production, processing, storage, transportation and distribution of natural gas to consumers is constantly monitored by dispatching services. Therefore, timely and accurate transmission of data on the parameters of technological processes, their correct interpretation and presentation (imaging) are among the main components of dispatching control. Today we are actively modernizing the entire dispatching control of the Unified Gas Supply System, providing control not only of technological processes, but also their connection with the financial and economic performance of Gazprom PJSC.

In dispatching activities, in order to carry out decision-making functions for the management of technological processes and the execution of contracts and agreements, it is increasingly necessary to resort to the help of systems that provide

computer support for decisions. The quality of dispatching solutions depends on several factors: the qualifications of operational dispatching personnel, the level of information transmission systems used, and the availability of decision support software.

Decision support information systems are a modern powerful tool in the hands of a dispatcher. Computer systems for dispatcher decision-making support today allow solving a wide range of dispatcher management tasks, including:

– ensuring fast work with dispatching information;

– displaying information on maps, diagrams, etc.;

– carrying out mathematical calculations for solving technological problems, making forecasts based on statistical data processing;

– generating reports and providing reports for management.

The widespread introduction and development of information systems, dispatch decision support systems requires close interaction between software developers and users. Here it is important to understand the specifics of the tasks set, to ensure fruitful cooperation of all participants in the process for their qualitative solution. We see this as one of the main goals of this conference. I would like to thank our parent research Institute of Natural Gases and Gas Technologies (Gazprom VNIIGAZ LLC), the forge of our personnel – National University of Oil and Gas "Gubkin University", our foreign and Russian participants for organizing and paying attention to this conference and wish us all further fruitful work.

GAZPROM VNIIGAZ

VII International Science and Technical Conference

# COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

October 14–15, 2021

General Director,
Gazprom VNIIGAZ LLC
**M.Yu. Nedzvetskiy**

**Dear colleagues!**

I am glad to welcome you to the VII International Science and Technical Conference "Computer Technologies of Decision Making Support in Dispatching Management of Gas Transmission and Producing Systems" hosted by Gazprom VNIIGAZ LLC and the National University of Oil and Gas "Gubkin University".

PJSC Gazprom's unique gas transmission system is the largest in the world, and comprises gas production, transportation, storage, processing and distribution facilities. Failure-free and effective operation of this system in many respects depends on its working modes management.

Gas transmission and producing dispatching management exists as long as the systems themselves. At the very beginning, dispatching control was almost straightforward. However, nowadays it became one of the most sophisticated research-and-technology challenges, as the Unified Gas Supply System encloses over 175 thousand kilometers of branched gas mains connected by technological lines, 254 compressor stations with over 3700 gas pumping units. This challenge is impossible to address without advanced programming and computing suites and information systems of decision-making support.

Modern information systems not only manage operation modes of gas transmission and production, but do it effectively, streamline gas flows and loads of compressor stations. Application of such technologies, as well as forefront of modern digital research is a hot issue for the industry. Scientific conference on

this topic, exchange of opinions and detailed discussion of innovations with no doubts will facilitate achievement of global goals and tasks of the gas industry.

It should not go unmentioned that our conference is held along with the sixtieth anniversary of the Central Production and Dispatching Department, which plays a specific role in PJSC Gazprom's structure. It integrates all gas transmission and producing companies of PJSC Gazprom, allows for online decision-making and ensures uninterrupted gas supplies under irregular gas consumption and its steady increase both in Russia and abroad.

I would like to wish all specialists of PJSC Gazprom's dispatch service new work achievements, health, well-being and all the best, and the conference participants – fruitful networking, new discoveries and success in addressing research and development tasks.

VII International Science and Technical Conference

# COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

October 14–15, 2021

Rector,
National University of Oil and Gas
"Gubkin University"
**V.G. Martynov**

**Dear friends, my most esteemed colleagues, organizers and participants in the VII International Scientific and Technical Conference "Computer Technologies of Decision Making Support in Dispatching Management of Gas Transmission and Producing Systems"!**

Almost two decades has passed since the first Conference took place in Gubkin University. Today we may note with satisfaction that it has become an established international venue for constructive dialogue, establishing successful contacts, demonstrating the latest innovations and sharing best practice in the field of dispatching management, a foundation of gas transmission and production complex management.

Computer technologies supporting decision making allow us not only manage unmatched in the world Unified system of gas supply but effectively manage it providing uninterrupted and reliable supply of natural gas to customers in Russia, countries across the former Soviet Union and beyond.

No matter how many discussions there are on the end of oil-and-gas era, power industry at this stage largely depends on extraction and consumption of organic fuel. Today there are no energy sources which would be able to compete with organic fuel in terms of availability, expansion and effectiveness.

Natural gas is the most perspective organic fuel considering insignificant ecological and climatic consequences of its use in energy generation, and already existing gigantic infrastructure for its consumption. Developed and smoothly operating transmission system and modern fuel and power equipment allow comparatively

cheap transmission of this source of energy practically in any spot in our planet and generation of the needed energy. All this allows us to make a conclusion that in 21st century natural gas will dominate in the global energy balance.

In this connection it is impossible to imagine sustainable development of power industry in satisfying growing demands of mankind without further and advanced development of extraction and use of natural gas for energy generation. It means that still new tasks will appear for dispatching management and information support of decision making, there is evidence of importance and relevancy of the problems to be discussed at the Conference.

I am sincerely wishing all participants in the conference fruitful work, establishing new contacts for future joint projects and effective cooperation, making interesting scientific conclusions and developing perspective practical recommendations. I wish you good health and all the best!

GAZPROM

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ГУБКИНСКИЙ УНИВЕРСИТЕТ
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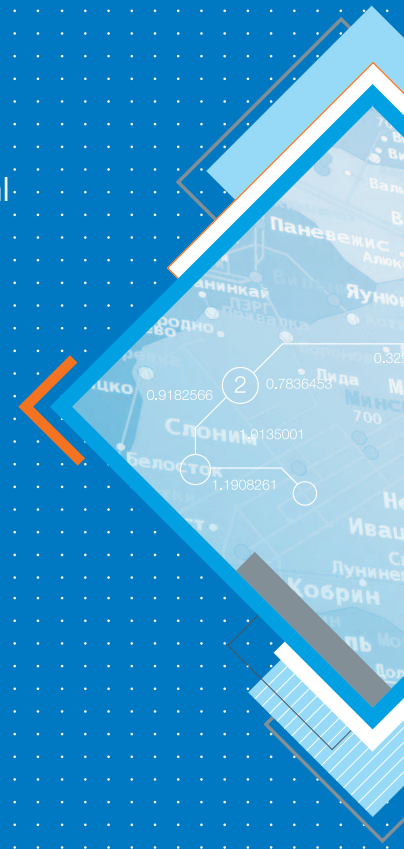


October 14–15, 2021
Moscow, Gazprom VNIIGAZ LLC

# CONFERENCE PROGRAM

GAZPROM VNIIGAZ

# ORGANIZING COMMITTEE

## VII International conference
## COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

**Razvilka** **Gazprom VNIIGAZ LLC**

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|---|---|
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| **DEPUTY CHAIRMEN:** | |
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| M.Yu. Nedzvetskiy | General Director, Gazprom VNIIGAZ LLC |
| V.G. Martynov | Rector, National University of Oil and Gas "Gubkin University" |
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| R.R. Kantyukov | Deputy General Director for Science, Gazprom VNIIGAZ LLC |
| A.S. Lopatin | Head of the Department, National University of Oil and Gas "Gubkin University" |
| D.M. Lyapichev | Head of the Corporate R&D Center for Gas Transmission Systems and Technologies Gazprom VNIIGAZ LLC |
| V.V. Rubel | Deputy Head of the Division, PJSC Gazprom |
| V.A. Shvechkov | Assistant professor, National University of Oil and Gas "Gubkin University" |
| K.A. Demyanov | Head of the Conference and Exhibition Department, Gazprom VNIIGAZ LLC |
| M.A. Plotnikova | Deputy Head of the Conference and Exhibition Department, Gazprom VNIIGAZ LLC |

# CONFERENCE SCHEDULE

## VII International conference
## COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

**Razvilka** **Gazprom VNIIGAZ LLC**

**ONLINE**

Presentation – 20 minutes

**14 October 2021, Thursday**

| | | |
|---|---|---|
| **9.00–10.00** | Communication tests, remote web access configuration, test connection | Workplaces of speakers and participants |
| **10.00–11.30** | **Plenary session** | Room 302, 3rd floor, E building |
| **11.30–12.00** | Break | |
| **12.00–13.20** | **Plenary session** | Room 302, 3rd floor, E building |
| **13.20–14.00** | Break | |
| **14.00–15.50** | **Panel A**<br>Automated systems and computer technologies in gas production, transmission and distribution | Room 302, 3rd floor, E building |
| **15.50–16.00** | Break | |
| **16.00–17.00** | **Panel A**<br>Automated systems and computer technologies in gas production, transmission and distribution | Room 302, 3rd floor, E building |

## 15 October 2021, Friday

| | | |
|---|---|---|
| **8.00–9.00** | Communication tests, remote web access configuration, test connection | Workplaces of speakers and participants |
| **9.00–11.00** | **Panel B**<br>Decision making support systems in dispatching management of gas transmission and producing systems | Room 302, 3rd floor, E building |
| **11.00–11.20** | Break | |
| **11.20–12.40** | **Panel B**<br>Decision making support systems in dispatching management of gas transmission and producing systems | Room 302, 3rd floor, E building |
| **12.40–13.30** | Break | |
| **13.30–15.30** | **Panel C**<br>Artificial intelligence technologies in dispatch control of gas supply systems | Room 302, 3rd floor, E building |
| **15.30–16.00** | Break | |
| **16.00–16.30** | **Closing Plenary Session** | Room 302, 3rd floor, E building |

# PROGRAM

## VII International conference
## COMPUTER TECHNOLOGIES OF DECISION MAKING SUPPORT IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

**Razvilka** **Gazprom VNIIGAZ LLC**

**ONLINE**

**14 October 2021, Thursday**

| | | |
|---|---|---|
| **9.00–10.00** | **Communication tests, remote web access configuration, test connection** | |
| **10.00–13.20** | **Presentations** | |
| **10.00** | **Conference opening**<br><br>Welcoming address by the General Director of Gazprom VNIIGAZ LLC **M.Yu. Nedzvetskiy**<br><br>Welcoming address by the Rector of the National University of Oil and Gas "Gubkin University" **V.G. Martynov** | |
| **10.10** | **P1** | **A.Yu. Kireev**<br>(PJSC Gazprom)<br><br>Analysis of the possibility of using artificial intelligence technologies in PJSC Gazprom's gas supply system control |
| **10.30** | **P2** | **D.M. Lyapichev**<br>(Gazprom VNIIGAZ LLC)<br><br>Estimating the impact of gas supply short-term changes on the technical state of equipment and pipelines of gas transmission systems: methodical approaches |
| **10.50** | **P3** | **A.O. Gorbunov**<br>(PSI LLC)<br><br>PSI LLC and PSI SOFTWARE AG innovative solutions in natural gas transmission and storage control |

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| **11.10** | **P4** | **A.A. Kovalev**<br>(JSC AtlanticTransgazSistema)<br>Import substitution and functional development of the SPURT/ SPURT-R programming and computing suite in 2015–2021 |
| **11.30–12.00** | **Break** | |
| **12.00** | **P5** | **V.A. Shvechkov**<br>(National University of Oil and Gas “Gubkin University”)<br>Organizational and methodical outlines for setting up an R&D test site for dispatch control of gas supply systems based on artificial intelligence technologies |
| **12.20** | **P6** | **D.G. Leonov**<br>(National University of Oil and Gas “Gubkin University”)<br>Development of the heterogeneous core architecture of distributed programming and computing suites to support dispatching decisions in gas transport |
| **12.40** | **P7** | **G.V. Zybin**<br>(PJSC Gazprom avtomatizatsiya)<br>PJSC Gazprom avtomatizatsiya experience in import substitution of PJSC Gazprom’s operational dispatch control systems |
| **13.00** | **P8** | **V.N. Yushmanov**<br>(PJSC Gazprom)<br>Introduction of innovative solutions for effective GTS management |
| **13.20–14.00** | **Break** | |

**14.00–17.00** **Panel A**
**Automated systems and computer technologies in gas production, transmission and distribution**

**14.00–14.10** Welcoming address by the Head of PJSC Gazprom's Department
**S.N. Pankratov**

**14.10–17.00** **Presentations**

**14.10** **A1** **A.S. Lopatin**
(National University of Oil and Gas "Gubkin University")

Natural gas – a basis for sustainable development of the global power economy

**14.30** **A2** **E.V. Kosolapova**
(Gazprom VNIIGAZ LLC)

Carbon footprint of PJSC Gazprom's natural gas: risks and opportunities

**14.50** **A3** **V.A. Schurovsky**
(Gazprom VNIIGAZ LLC)

Energotechnological methodical approaches to the processes of gas transmission via gas mains

**15.10** **A4** **G.I. Namestnikov**
(Nizhegorodsky branch of Gazprom proektirovaniye LLC)

Modeling of gas mains systems for automated design solutions during expansion and construction of new multiline branched gas pipelines: related challenges for PS designers

**15.30** **A5** **V.A. Marishkin**
(Gazprom dobycha Noyabrsk LLC)

Modern technical data analysis and visualization solutions implemented at ODCS of Gazprom dobycha Noyabrsk LLC

**15.50–16.00** **Break**

**16.00** **A6** **V.V. Teterev**
(Gazprom inform LLC)

Introducing PTP IMS template at PJSC Gazprom's subsidiaries: current status and prospects

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| **16.20** | **A7** | **K.M. Togunov**<br>(Gazprom dobycha Astrakhan LLC)<br>Experience in equipping dispatching services with an information visualization system |
| **16.40** | **A8** | **S.A. Bujnovskiy**<br>(CJSC STC ISPR)<br>TOXI+ software line to estimate consequences and risks of hazardous emissions |

**ONLINE**
**15 October 2021, Friday**

| | |
|---|---|
| **8.00–9.00** | **Communication tests, remote web access configuration, test connection** |
| **9.00–12.40** | **Panel B**<br>**Decision making support systems in dispatching management of gas transmission and producing systems**<br>**Presentations** |

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|---|---|---|
| **9.00** | **B1** | **R.B. Yakovlev**<br>(PJSC Gazprom)<br>Modelling of gas transmission systems of PJSC Gazprom's subsidiaries to detect and localize gas imbalances |
| **9.20** | **B2** | **S.V. Evseev**<br>(Branch of the RFNC VNIIEF Yu.E. Sedakov NIIIS)<br>Development and introduction of a subsystem for detection of emergency situations |
| **9.40** | **B3** | **V.V. Samsonova**<br>(National University of Oil and Gas "Gubkin University")<br>Experience in developing a programming computing suite for modeling two-phase flow of a multicomponent mixture for the conditions of the Chayandinsky OGC field |

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| **10.00** | **B4** | **S.V. Varakin**<br>(Sirius Soft LLC)<br><br>Development of comprehensive technical solutions for operational dispatch control systems of gas industry enterprises: sophisticated domestic approaches |
| **10.20** | **B5** | **G.V. Kaspiyev**<br>(Gazprom transgaz Ukhta LLC)<br><br>Volna PCS as a dispatch decision-making tool. Non-stationary calculation of compressor shop's equipment operation |
| **10.40** | **B6** | **S.V. Komissarov**<br>(Gazprom inform LLC)<br><br>Development of Astra-gas and other programming and computing suites at PJSC Gazprom: current and future challenges |
| **11.00–11.20** | **Break** | |
| **11.20** | **B7** | **V.V. Kiselev**<br>(Gazprom transgaz Tomsk LLC)<br><br>Volna programming and computing suite: user experience at Gazprom transgaz Tomsk LLC |
| **11.40** | **B8** | **R.S. Gupalov**<br>(Gazprom EP International B.V.)<br><br>Digital Production Facility Monitoring System (PFMS) platform as a tool of improved oil and gas project management |
| **12.00** | **B9** | **M.G. Gilyaziev**<br>(Engineering and Technical Center of Gazprom transgaz Kazan LLC)<br><br>Development, introduction and debugging of the monitoring system for the integral energy efficiency parameter of centrifugal superchargers at gas compressor units |
| **12.20** | **B10** | **V.V. Zubalev**<br>(Gazprom transgaz Yugorsk LLC)<br><br>Automation of gas pumping unit's performance control |
| **12.40–13.30** | **Break** | |

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| **13.30–15.30** | **Panel C**<br>**Artificial intelligence technologies in dispatch control of gas supply systems**<br>**Presentations** | |
| **13.30** | **C1** | **A.V. Belinsky**<br>(NIIgazekonomika LLC)<br>Modeling, optimization and management of the operation modes of the Unified Gas Supply System of Russia with the use of artificial intelligence technologies |
| **13.50** | **C2** | **F.N. Mirsaitov**<br>(Innopolis University ANCO NBO)<br>A machine learning method for detecting defects and pipeline features obtained using magnetic pig flaw detectors |
| **14.10** | **C3** | **V.V. Yuzhanin**<br>(National University of Oil and Gas “Gubkin University”)<br>Cyberphysical systems and educational process |
| **14.30–15.10** | **Round Table “Artificial intelligence technologies in dispatch control of gas supply systems”** | |
| **15.30–16.00** | **Break** | |
| **16.00–16.30** | **Closing Plenary Session** | |

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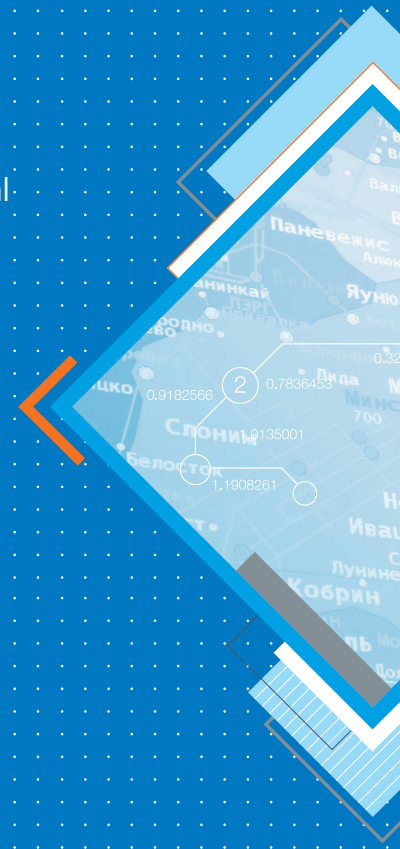


October 14–15, 2021
Moscow, Gazprom VNIIGAZ LLC

## ABSTRACTS

GAZPROM VNIIGAZ

## Analysis of the possibility of using artificial intelligence technologies in PJSC Gazprom's gas supply system control

*A.Yu. Kireev (Gazprom PJSC)*

In 2021, April 12 marked the 60th anniversary of the first dispatcher shift. Since then, the control and management of the Gazprom gas transportation system has not been interrupted for a second. During this time, the gas transportation system itself and its dispatching control system have come a long way in their development, from several main gas pipelines to modern unified gas supply system, from «manual» control based on the experience and professional skills of dispatchers, to understanding that in the current conditions, the GTS control system is a comprehensive process requiring the use of new artificial intelligence and machine learning technologies that automate the process of dispatching control. At the same time, the requirements for the experience and professional skills of dispatchers remain at the same high level.

Digitalization is a modern trend in any industry, including oil and gas, where there are more and more new areas of application for digitalization as a tool for optimizing technological processes. The proposed paper describes the features of artificial intelligence and machine learning in comparison with natural human intellectual capabilities, shows their main advantages and disadvantages in comparison with traditional methods of solving regression problems and clustering problems. The paper presents a classification of tasks depending on the complexity of the reaction to a change in the external environment for the tasks of human reactions and production management tasks. One of the most common machine learning algorithms, called a decision tree, was briefly described, and various implementation options for this method were considered and evaluated. The result of the work is the presentation of the concept of the functioning of process control systems in the GTS using a proactive approach, which makes it possible to optimally choose the operating modes of the equipment, taking into account the predictive state of the GTS.

It is necessary to take into account that the gas supply system of Gazprom PJSC is unique and does not even have close analogues in world practice, for this reason it is unlikely that we can use existing developments and algorithms, that is, our algorithms are likely to be unique as well.

## Estimating the impact of gas supply short-term changes on the technical state of equipment and pipelines of gas transmission systems: methodical approaches

*D.M. Lyapichev (Gazprom VNIIGAZ LLC)*

Reliable and efficient operation of gas transmission systems can only be ensured by the availability of up-to-date data on the technical condition of equipment and pipelines of the facilities within those systems.

Gas transmission systems are highly sophisticated technological complexes with very specific operating conditions. One of the features of operating the gas transmission systems is the presence of both seasonal (long-term) and daily (short-term) irregularities in gas consumption, resulting in multiple changes in their operating conditions over time.

Many papers are assessing the nature and causes of changes in gas consumption, but only a limited number of papers are assessing the impact of changes in gas consumption on the operational and technological parameters of gas transmission systems as well as on changes in their technical condition.

Therewith, the need to consider the effect of changes in operating modes on the condition of gas transmission systems is indicated in individual studies of the effect that the number of start-stops and different operating modes have on the service life of gas transmission equipment and the effect of pressure fluctuations on process pipelines.

Within the work presented, methodical approaches are offered to estimate influence exerted by changes in gas transmission systems' operational and technological parameters on the technical condition of equipment and pipelines of the facilities within those systems, results of estimation of influence of variable loading on the pipeline elements resource, the pressure vessels, and the speed of development of cracks-like defects in the base metal and welded joints of pipelines are exhibited.

It is shown that one of the required stages of systematic work to optimize the operation of gas transmission systems should be the integration of automated technical diagnostics systems with decision support systems in dispatch control.

Proposals are provided on the application of state-of-the-art digital technology for accounting the influence exerted by repeated changes of operating and technological parameters when estimating the technical condition and forecasting the residual resource of technological equipment and pipelines of gas transmission systems.

## PSI LLC and PSI SOFTWARE AG innovative solutions in natural gas transmission and storage control

*A.O. Gorbunov (PSI LLC)*

PSI LLC is a Russian subsidiary of the German company PSI Software AG, which has specialized in software for dispatching of natural gas transportation, distribution and storage for more than 50 years. PSI Gas management is the basis for almost all of the dispatch systems of Gazprom's partner companies in Germany.

Since 2005 PSI Gas management and its localized analogue PSIgas have been successfully applied in Gazprom in large-scale projects: MASDU, SODU GTO, dispatch system as a part of UGS. PSI software is distinguished by its comprehensive and integrated approach to management tasks and flexible adjustment to the current business process model.

PSI has been localizing the software in Russia since 2015. In 2016 the PSIgas complex was included in the unified Register of Russian Programs. In 2019 the Gorizont created by OOO GA Dispatching Systems, a joint venture of PSI and Gazprom avtomatisatsiya, passed acceptance testing by PAO Gazprom. PSI is ready to continue localization and substitution of software with high sanction risks with Russian partners.

As a part of own scientific research, the functionality of PSI Gas management is being expanded in terms of integration with the PSIganesi modeling and forecasting system PSIprognosis. The integration of real-time SCADA, simulation and forecasting provides the dispatcher with a powerful tool for the safe management of the gas grid. Integration of surface pipeline system simulation and underground UGS or gas field simulation improves gas recovery and reduces gas losses.

In the area of artificial intelligence in dispatching, PSI in 2019 developed a prototype of the PSIgasguide Intelligent Decision Support System (IDSS) for GTS management using a non-stationary GTS model and Qualicision® fuzzy logic-based system (in-house development).

Elements of fuzzy logic and artificial intelligence of the innovative product PSIcommand automate the processes of planning and management of gas grid and geographically distributed facilities maintenance specialists.

A unified software environment PSI JAVA Framework (PJF) was created and brought to the level of industrial application. PJF is available to partners for development of additional functionality.

PSI products can be used to upgrade existing systems and create new modern IT solutions.

## Import substitution and functional development of the SPURT/SPURT-R programming and computing suite in 2015–2021

*A.A. Kovalev (JSC AtlanticTransgazSistema)*

Since its foundation in 1992, JSC AtlanticTransgazSistema (ATGS JSC) has been working for Gazprom specializing in design, manufacture, supply and implementation of Supervisory Control Systems based on SPURT software and hardware complex, as well as Supervisory and Automation Systems based on STN-3000 software and hardware complex. Both systems are of ATGS proprietary production. Created in 1990s, they are in constant development, meeting current requirements of customers and modern level of information technologies and automation tools. As of 2021, SPURT is a platform for Automated Dispatch Control Systems of five gas transportation companies, in many other companies SPURT is used as the basis for supervisory control of pipelines and gas fields. In total, more than 200 SPURT servers are installed.

In 2015-2017 SPURT underwent some major adjustments – its software and technical components were substituted by components produced in Russia and countries not supporting sanctions policy against the Russian Federation. The new version – SPURT-R – as a part of Dispatch Control System and Decision Making Support System (DMSS) has passed all the necessary acceptance tests of Gazprom PJSC. The first implementation object of SPURT-R as a platform for a multi-level multifunctional Automated Dispatch Control System was Gazprom Kyrgyzstan (2019).

Having carried out substitution for import components, ATGS specialists continue to expand the functionality of SPURT-R. Works are carried out in several directions: development of integration with a non-stationary model of gas transmission system (Volna complex) with gas consumption forecasting and implementation of proactive control of GTS; functionality development of dispatcher's log modules, planning, balancing and DMSS reporting; new solutions in support of decision-making in emergency situations; creation of analytical applications for early diagnosis, localization and identification of equipment malfunctions, etc.

Overall, SPURT-R development is carried out within the framework of the general trend of Gazprom's digital transformation and contributes to improving reliability and efficiency of GTS management in the Russian Federation.

## Organizational and methodological foundations for establishment of a scientific and production testing ground for solving problems of dispatching control of gas supply systems based on artificial intelligence technologies

*V.A. Shvechkov (National University of Oil and Gas "Gubkin University")*

The rapid introduction of digital technologies and systems based on artificial intelligence is widely used in various industries. An increase in the level of automation of gas supply systems and a reduction in the frequency of collecting operational data of television measurements has led to the formation of large arrays of historical data that can be processed using a wide range of data mining technologies.

Artificial intelligence technologies based on neural networks have found successful application in areas where it is either impossible to use traditional mathematical models to identify connections between the parameters of distributed systems, or inefficient due to the huge dimensionality of the systems under consideration.

The use of neural networks in the tasks of dispatching control of gas supply systems should be based on the technological base of the retrospective operational and technological parameters of gas supply systems available in the Automated dispatch control systems. The neural network self-learning model is a new intelligent adaptive element of the dispatching decision support system that allows solving the following urgent tasks: analyzing the current state of the UGS, taking into account forecast data on gas consumption, applications for gas supplies for export, and also taking into account forecast data on climatic conditions to form a forecast for the state of the UGS with a depth of 24 to 72 hours.

The effective solution of the tasks of dispatching control of gas supply systems based on artificial intelligence technologies is possible by creating a joint research and production site based on the branch institutes of Gazprom PJSC. Specialists of specialized institutes of Gazprom PJSC and Gubkin University will form the basis of a joint competence center in the field of artificial intelligence. The introduction of additional disciplines into the curricula of the departments of Gubkin University, the allocation of grants for the targeted attraction of talented students and postgraduates will allow the formation of personnel potential for the gas industry and ensure the development of this area of research on a long-term basis.

Solving problems of the UGS scale requires significant computing resources for data processing and training of multilayer neural network models. The solution to this problem is possible by using the capacities available from leading technical universities and technology companies. The approbation of algorithms and technical solutions obtained at the research and production ground will make it possible to form reasonable requirements for the resource support of the technical infrastructure of Gazprom PJSC.

## Development of the heterogeneous core architecture of distributed software and computing package to support dispatching decisions in gas transport

*D.G. Leonov, T.M. Papilina (National University of Oil and Gas "Gubkin University")*

The paper discusses the development of the architecture of software and computer packages for dispatching decision support (DDS SCP), based on the use of an open integration platform that ensures the functioning of packages in a heterogeneous environment.

The main integration solutions and mechanisms that ensure the construction and evolutionary development of the SCP were tested during the development of the Vesta SCP, and applied later in the development of a software training package that implements the modeling of gas transportation preparation processes. This architecture provides for both the traditional local mode of operation on personal computers running the main operating systems, and functioning in the cloud service mode to perform training tasks and evaluate the actions of trainees.

An essential factor in the development of new generation software packages is the requirement of functioning in open operating systems, due to the policy of import substitution. In this regard, the Qt 5 library is used as the main software platform providing the local mode of operation of the package; the cloud mode of operation is implemented on the .NET 5.0 platform. The interaction of heterogeneous components of the SW package takes place using a message transmission mechanism based in the current implementation on the RabbitMQ broker.

Functioning of the software package has been tested in Windows 10, Linux Ubuntu 21.04 and macOS 11 operating systems.

## PJSC Gazprom Gazprom Avtomatizatsiya experience in the field of import substitution in operational dispatch control systems Gazprom PJSC

*G.V. Zybin (PJSC Gazprom avtomatizatsiya)*

Since 2015, the Government of the Russian Federation, the Ministry of Digital Development of the Russian Federation and Gazprom PJSC have adopted a number of regulatory documents defining the directions of import substitution in organizations with state participation. One of such directions is the replacement of imported software used in various automated control systems, in particular, in operational dispatch control systems (hereinafter the ODCS).

In addition, in 2018, Federal Law of the Russian Federation No. 187-FZ of 26.07.2017 On the Security of the Critical Information Infrastructure of the Russian Federation came into force, according to the requirements of which, mainly software of Russian origin should be used in critical information infrastructure facilities.

At the same time, it is worth noting that most of the ODCSs currently being operated in subsidiaries of Gazprom PJSC are built using both system and special software of foreign origin.

In accordance with STO Gazprom 2-1.15-680-2012, two subsystems are distinguished as part of the ODCS:

- Dispatching control and management system (DCMS);
- Dispatcher decision support system (DDSS).

Gazprom Avtomatizatsiya PJSC has developed, tested and recommended two software packages (hereinafter the SPs) that meet the requirements of import substitution and security of critical information infrastructure facilities for the construction of gas transportation facilities:

- Horizon SP (No. 4476 in the Unified Register of Russian Programs);
- Potok-DU SP (No. 5621 in the Unified Register of Russian Programs).

Software and hardware packages based on them have INTERGAZSERT certificates and are included in the register of tools recommended for delivery to the facilities of Gazprom PJSC.

Currently, the Potok-DU SP is being prepared for testing as a DCMS for gas production facilities.

In 2020, Gazprom Avtomatizatsiya PJSC successfully completed the R&D «Development of algorithms and models for remote control of industrial safety of hazardous production facilities Gazprom Dobycha Astrakhan LLC».

Using the experience gained as a result of these works in the field of building an information system, Gazprom Avtomatizatsiya is currently completing improvements to the Potok-DU SP, which allow for the implementation of the DDSS functionality.

Thus, the software packages developed by Gazprom Avtomatizatsiya PJSC will allow for the construction of gas production and transportation facilities of Gazprom PJSC, taking into account the requirements of import substitution and the security of critical information infrastructure facilities of the Russian Federation.

## Introduction of innovative solutions for effective GTS management

*V.N. Yushmanov (PJSC Gazprom)*

An integrated corporate system for implementation of innovations was created in PJSC Gazprom in 2018 aimed to integrate expertise of administration, representatives of Company's subsidiary operators and research centers.

The corporate system for implementation of innovations is equipped with a set of tools required for effective operation. Key element of the Corporate system is a permanent Commission responsible for the implementation of innovative products involving representatives of departments from Investments and Strategy, Production and Finance and Economics blocks of PJSC Gazprom.

The Commission is authorized:

- to take decisions on inclusion of products in the Register of Innovative Products and Uniform Register of Material and Technical Resources approved for use in PJSC Gasprom;
- to coordinate measures, sources of finance and facilities required for implementation of innovative products.

Besides, the Commission takes decisions on the implementation of energy-saving projects involving the use of the mechanism of energy service agreements.

Another instrument of implementation of innovative products is a Coordination Council for implementation of innovative products organized together with Innopraktika, and a Joint Design Office operating under its guidance.

At this time a number of innovative developments is in the implementation stage in PJSC Gazprom, including those developed in the framework of PJSC Gazprom R&D Program. They include:

- Volna programming and computing complex for modelling operation modes in natural gas transmission systems;
- Hygrosence dew point sorption/capacitance temperature convertion tool for measuring natural gas moisture content, etc.

Active implementation of digital technologies is carried out. Realization of Digital Twin pilot project is in the final stage at of the Yuzhno-Russkoye Field, with termination planned for early next year. A similar project has already been initiated for Kirinskoye Field on the base of this pilot project.

The Corporate system for implementation of innovations is constantly being improved to increase operational efficiency. Work is carried out together with Saint Petersburg State University of Economics to develop and commission an information and control system for expert and analytical support of innovation implementations called 'Gazprom. Territory of Innovations' on the base of 'one window approach' web portal. A number of documents is being developed for the refining of regulatory and procedural foundation.

# PANEL A
# AUTOMATED SYSTEMS AND COMPUTER TECHNOLOGIES IN GAS PRODUCTION, TRANSMISSION AND DISTRIBUTION

## Natural gas – a basis for sustainable development of the global power economy

*V.G. Martynov, V.V. Bessel, V.G. Kucherov, A.S. Lopatin, R.D. Mingaleeva*
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The prediction of the end coming for the oil and gas era has lately taken some place among the most debated issues. Even BP, Total, and many other oil giants have joined the pessimistic forecasts of the so-called carbon energy industry.

While the end of the oil and gas era was once predicted to be primarily a case of depleting reserves, today environmental, climatic, economic, and political factors have been added to the justification for this scenario, which can often be interpreted in exactly the opposite ways. That leads to the view that the end of the oil and gas era is an imminent reality for some people while being little more than a fashionable and unlikely trend to be realized any time soon – for the others.

At the present technological stage of development, the energy sector is in crucial dependence on fossil fuels production and consumption, which include natural gas, oil, and coal, while fossil fuels accounting for over 80 % of the world's energy consumption. Today there are no energy sources that would be able to compete with organic fuel in terms of availability, expansion, and effectiveness. On the flip side, it is obvious that the world's energy future can be barely imagined without renewable energy sources (RES). However, claims of a complete switchover to energy generated by wind, solar, and geothermal sources – voiced by many politicians and public figures – are unlikely to have reasonable substantiation. Nor is it all that straightforward with hydrogen power where the majority of existing problems is far more unsolved than solved.

Natural gas is the most energy-efficient fossil fuel. A well-developed infrastructure for natural gas transportation, both via long-distance pipelines and in liquefied form, as well as a constantly developing and improving infrastructure for its consumption, make natural gas the most efficient and affordable fossil fuel. State-of-the-art technologies for using gas allow for minimizing the volume of harmful emissions, making natural gas the most environmentally friendly fossil fuel.

One way to improve the efficiency and reliability of energy supply, especially in remote regions with poor energy infrastructure, would be to "hybridize" energy supply by coupling the joint use of centralized fossil fuel-fired and, above all, natural gas-fired thermal generation facilities with combined heat and power plants using renewables and energy storage units.

In this context, a sustainable energy strategy dedicated to satisfying humanity's growing energy needs can be defined as the further and advanced development of natural gas production and use for energy purposes as well as significant investments in the development of «hybrid» technologies.

## Carbon footprint of PJSC Gazprom's natural gas: risks and opportunities

*E.V. Kosolapova (Gazprom VNIIGAZ LLC)*

With evolution of the accords under the Paris Climate Agreement and while countries and global energy corporations are adapting for the low-carbon economy trend, the carbon footprint from natural gas may shape both risk and further opportunities for technological development of Gazprom PJSC.

The risk arising in the activities of Gazprom PJSC to reduce the carbon footprint generated by natural gas may be due to transformations in the policies, legislation, applied technology and market requirements with a view to preventing climate change. For example, the introduction of GHG emission regulation mechanisms that are based on restrictive provisions and standards, the impact of technological improvements/innovation on business competitiveness, and changes in energy supply and demand may result in extra costs for the company.

The global economic development provides for growing use of low-carbon energy resources, including natural gas. This generates new opportunities for the use of natural gas produced by Gazprom PJSC and we can expect, among other things:

- further leadership of natural gas in the interfuel competition (oil, coal and gas) in the European and global energy markets both in the short term until 2035 and in the future until 2050;
- natural gas to retain its position of primary precedence in terms of amounts supplied to European countries, including due to the carbon-related competitive advantages of Russian natural gas within the entire workflow and due to quick diversification of supplies in ensuring industrial and environmental safety;
- access to new markets and natural gas delivery through transmission pipelines and/or on board LNG carriers to those countries that decide to wean themselves off coal (e.g., India or China);
- production and use of pure hydrogen that will be produced carbon-free from Russian natural gas supplied in a conventional manner through the existing gas transmission system to where it will be generated and consumed in Europe.

There are multiple international techniques used for measuring GHG emissions throughout the natural gas life cycle in order to calculate product carbon footprint. The techniques have been analyzed in order to determine whether they are applicable to the Russian realities and to the Russian oil and gas sector. The analysis has revealed restrictions that prevent from applying the techniques in calculations of carbon footprint from natural gas supplied by Gazprom PJSC throughout the workflow.

Experts at Gazprom VNIIGAZ LLC have developed a calculation technique for carbon footprint from the well-to-consumer natural gas life cycle, which can be used as a basis for developing a GHG emissions/carbon footprint software suite for various options of natural gas supplies by Gazprom PJSC.

The updated technique is currently applied to calculate carbon footprint from natural gas produced and exported by Gazprom PJSC through different routes, such as the Ukrainian transit corridor (Urengoy-Uzhgorod, Yelets-Kremenchug-Krivoi Rog), Belarus transit corridor (Yamal-Europe), Nord Stream, and Nord Stream 2.

## Energotechnological methodical approaches to the processes of gas transmission via gas mains

*V.A. Schurovsky (Gazprom VNIIGAZ LLC)*

The design and operation of multi-run gas transmission systems based on the principles of the «unified hydraulic regime (UFR)» has obvious advantages in increasing system reliability and improving complex technical and economic indicators. However, the UFR is not energetically optimal,

It is recommended to update the meaning and procedure of using the coefficients of hydraulic resistance, friction resistance and hydraulic efficiency of the MG section in the RTD.

The indicator of equivalent goods transport work used in the energy management system is not scientifically and technically sound and should be replaced by a correct energy technology standard.

The influence of hydraulic utilities of the CS is proposed to be estimated by their actual configuration in the form of an additional equivalent length of the section, which for a typical CS is about 12 km.

On the basis of classical ideas about the gas dynamics of gas movement in pipes, the dependences of commodity transport work, power, energy intensity and energy efficiency of the main gas pipeline on the gas velocity in the pipes are proposed.

## Modeling of gas mains systems for automated design solutions during expansion and construction of new multiline branched gas pipelines: related challenges for PS designers

*G.I. Namestnikov (Nizhegorodsky branch of Gazprom proektirovaniye LLC)*

Thermohydraulic calculations are an integral part of all design stages when developing projects for the construction of new facilities, as well as reconstruction and expansion of existing facilities. As a rule, all construction and reconstruction projects of gas transmission systems begin with these calculations.

Taking into account the current trends in the development of science, especially in the direction of AI, the most promising and necessary approaches for the implementation of hydraulic calculations, which should significantly increase labor productivity and the quality of design decisions, is the establishing SPs that allows for automatic determination of the parameters of the optimal option for expansion and construction of new MG systems with an appropriate assessment of development costs.

The complex should automatically, along with the construction of the hydraulic regime, determine the best solution for choosing the optimal route, operating pressure, diameter MG, parameters of loops, location and equipment of the CS, taking into account the dynamics of the capacity commissioning. Currently, design engineers mainly use SP Astra-gaz, Ingir, and the like. Unfortunately, these programs are significantly outdated and cannot find a technological solution themselves. The programs essentially only check the solution proposed by the calculator for the installation of a GPU, the development of a linear part, the construction of a CS for sufficiency and acceptability from the point of view of constructing a hydraulic regime when supplying specified volumes of gas and meeting the boundary conditions for flow, pressure and temperature. That is, to put it simply, they work as they did at the end of the last century, only it became possible to count large gas transmission systems and corridors «in one go» and due to the use of modern computers, the counting speed has increased.

In modern conditions, we should already be talking about the integration of hydraulic calculations with 3D models. Unfortunately, there are many mathematical, software, computer and other problems on the way that need to be solved on the widest scale. The experience of Giprogazcenter JSC on the establishment of Optima SP has shown that these works need to be accelerated and enhanced. Otherwise, we will start using self-driving cars, there will be widespread of AI, and we will still count at the same level as we did 20–30 or more years ago.

Proceeding from the above, I propose to expand the topic of discussion of pilot projects for the creation of new computational algorithms and SP modeling and optimization of the modes of operation of the GTS and the UGS as a whole, including the task of constructing the best design solutions for choosing the optimal route, operating pressure, MG diameter, looping parameters, location and equipment of the CS, taking into account the dynamics of capacity commissioning. Taking into account the existing experience in establishing the Optima SP, Gazprom Proektirovanie LLC NB is interested in participating in solving this issue.

## Modern technical data analysis and visualization solutions implemented at ODCS of Gazprom dobycha Noyabrsk LLC

*V.A. Marishkin, O.E. Ledevich, A.N. Khoma (Gazprom dobycha Noyabrsk LLC)*

Gazprom Dobycha Noyabrsk LLC has implemented an operational dispatch control system (ODCS), which includes a data collection, storage and processing system, a process modeling system, a training complex, and modern information display systems using business analytics systems.

A full cycle of collection, preparation and analysis of technological data has been implemented using modern software and hardware, including OLAP technologies and analytics systems The functions of the analytics system, such as quick measures and grouping, allow users to use more than 80 modern visualization tools to analyze data more deeply and identify patterns that might otherwise go unnoticed.

Together with Gubkin Russian State University of Oil and Gas, a training complex for dispatching planning and control of technological modes of gas production facilities was developed and is being operated. Currently, the simulator is being finalized taking into account the specifics of the gas production and treatment technology at the Chayandinskoye field.

The main area of application of the training complex is:

- training and advanced training of dispatching personnel;
- solving problems of modeling, planning, and managing the modes of gas production facilities as part of a dispatcher decision support system.

In order to fulfill the obligations of Gazprom PJSC's policy in the field of energy efficiency and energy saving, representatives of Gazprom dobycha Noyabrsk LLC and Gazprom VNIIGAZ LLC carried out a research work on the topic «Analysis and evaluation of the energy efficiency of Gazprom Dobycha Noyabrsk LLC gas production company in the conditions of reducing reservoir gas pressure». The results of this work were the development of a methodology for assessing energy efficiency as well as the establishment of an information system for analysis, operational control and management of energy efficiency of gas production facilities.

The enterprise has implemented one of the most modern ways of organizing the deployment of a data collection system – the use of virtual machines, the advantages of which have been repeatedly verified: minimum deployment time of the dispatcher's workplace and fault tolerance. The reduction of physical servers reduces power consumption, heat generation and noise, reduces the cost of purchasing backup equipment, centralization of management, and dynamic infrastructure.

Thus, the totality of the software and system-technical infrastructure of the ODCS at Gazprom Dobycha Noyabrsk LLC allows for reliable, safe and efficient management of hydrocarbon production and preparation facilities at facilities in the Yamalo-Nenets Autonomous District, Yakutia, and Kamchatka Krai.

## Introducing PTP IMS template at PJSC Gazprom's subsidiaries: current status and prospects

*V.V. Teterev (Gazprom inform LLC)*

The tasks of unification of software solutions used to automate dispatch control processes in subsidiaries of Gazprom PJSC were set in 2008 as part of the implementation of the Gazprom Informatization Strategy. At the same time, the main goals of the Informatization Strategy for dispatching management in the subsidiaries are relevant at the present time:

1. In subsidiaries of the Gazprom Group of companies, a significant number of heterogeneous industrial systems established on the basis of various software products are used to solve the same type of tasks.

2. A significant part of the systems was put into operation in the 1990$^{s}$ and 2020$^{s}$, requires development and import substitution with the transfer to new hardware platforms. At the same time, this need exists for systems put into operation after 2010.

3. In most cases, the systems used provide solutions mainly to local tasks of subsidiaries, without solving corporate-level management tasks. A sufficiently low degree of vertical integration makes it difficult to promptly obtain detailed production and technological information, which reduces the value of the information provided for managerial decision-making, increases the duration of planning cycles and reporting.

4. There is no single data model and a single NRD system necessary for the entire complex of production tasks. In the existing systems, in most cases, local management of the NRD is used.

As part of the Gazprom PJSC Informatization Strategy, since 2008, information management systems (IMS) of production and technological processes (PTP) have been developed and implemented in the subsidiaries, the implementation of which was carried out during the following projects:

- preparing an IMS P template for the type of activity Gas and gas condensate transportation – P T IMS (Samara);
- preparing an IMS P template for the type of activity Underground gas storage – P UGS IMS;
- preparing an IMS P template for the type of activity Gas and gas condensate extraction – P E IMS (Astrakhan);
- preparing an IMS P template for the type of activity Gas and gas condensate processing – P P IMS (Surgut);

These projects for the development and implementation of PTP IMS were not coordinated among themselves, the basic software belonged to various foreign vendors, as a result, a single PTP IMS template and a unified software platform have not been developed.

Due to the lack of a suitable solution for the next P E IMS and P T IMS projects, Gazprom Inform LLC began developing its own information platform several years ago. At the moment, the implementation and testing of a single template for operational dispatch control systems of various industry orientation is underway. The applied software architecture of operational dispatch control systems (ODCS) is built on the basis of free SW, import-substituted and multiplatform solutions. A deeper integration with top-level corporate systems is being

designed, which involves the end-to-end execution of business processes at different levels of management, the exclusion of user work in several information systems. The developed solutions are based on the principle of an open structure for the formation of a calculation model, with the possibility of visual configuration and representation of calculations in the form of graphs, which allows you not to resort to the services of developers when forming balance models and configuring the execution of various calculations.

Current implementations of the PTP IMS cover the main functionality of the ODCS in terms of support systems for dispatching decisions, without taking into account modeling complexes. The main goal of the new stage of the development of ODCS is to refine the software platform in terms of integration tasks with solutions from various manufacturers of modeling complexes and regime-technological calculations, dispatch control and management systems, BI and predictive analytics systems, as well as bringing to a new level of integration with ERP and VIR systems, offering businesses new solutions for planning and monitoring the activities and resources of industrial enterprises from among the Gazprom Group companies, and also bringing it closer to the creation of full-fledged digital counterparts of Gazprom's industrial facilities at the corporate level.

## Experience in equipping dispatching services with an information imaging system

*K.M. Togunov (Gazprom Dobycha Astrakhan LLC)*

When performing the tasks of the production and dispatch service, the problem of managing the information coming to the dispatch room inevitably arises. To eliminate this problem, it is necessary to create an information environment that allows to quickly and efficiently receive data, process, analyze them and make decisions, as well as visualize information, make it visual and intuitive. This information environment should be organized in the form of a system of collective information display (SCID). This system was developed and implemented in the dispatching services of Gazprom Dobycha Astrakhan LLC.

Currently, the SCID is used to visualize technological processes, visually monitor the operation of hazardous production facilities and personnel actions online, as well as monitoring the environmental and fire situation.

The comprehensive system of monitoring, prevention and preparation for localization and liquidation of emergency situations at hazardous production facilities is considered in detail.

## TOXI+ software line to estimate consequences and risks of hazardous emissions

*S.A. Bujnovskiy (CJSC STC ISPR)*

The presentation deals with two problems relevant to the field of industrial safety based on of specialized software complexes TOXI+.

**Problem No.1.**

Justification of technical solutions at hazardous production facilities in order to reduce the risk of accidents.

Hazardous production facilities (HPF) design and operation must be carried out according to the norms established by the legislation of the Russian Federation. However the innovative development in the field of technologies used at hazardous industrial facilities leads to unconditional lagging of normative-legal regulation. Special Technical Conditions and Safety Rationale for hazardous production facilities were introduced to eliminate this shortcoming.

These procedures make it possible to develop individual industrial safety requirements for design and operation of HPF. Such individual requirements must be justified far and away.

The main tools for justification technical decisions at HPF are currently physical and mathematical modeling of physical processes, as well as quantitative risk assessment of hazardous substances accidents.

**Problem No.2.**

Impact assessment of the consequences of an accident occurred.

Hazardous substances accidents have a potential to extend beyond the production facility lead to third-party casualties. It is all-important to have information of extent and probable consequences of an accident to make quick decisions in emergency situations.

Full information about the possible consequences of an accident could be obtained by applying modern approaches to physical and mathematical modeling of releases of hazardous substances. Real weather conditions and emergency emission detection systems data are intended to the modeling.

# PANEL B
# DECISION MAKING SUPPORT SYSTEMS IN DISPATCHING MANAGEMENT OF GAS TRANSMISSION AND PRODUCING SYSTEMS

## Modelling of gas transmission systems of PJSC Gazprom's subsidiaries to detect and localize gas imbalances

*R.B. Yakovlev (PJSC Gazprom)*

Gas losses are inevitable in the process of transportation due to a number of reasons:

- Non excluded systematic measurement error in gas flow metering.
- Diurnal and seasonal variations in physical and chemical properties of transported natural gas.
- Method errors in calculating the amount of natural gas used for own needs.
- Method errors in calculating the volume of natural gas in the Gas Transmission System (GTS) in the calculation period.
- Gas leaks in GTS facilities not eliminated due to impossibility of breaking gas transmission process.

Other losses due to errors in gas metering.

Task: Localization of source and remedial measures to eliminate gas losses of calculation and methodical nature (hereinafter, LCMN).

Very often this task is not a trivial one, and it involves the use of specialized analytical systems including gas transmission network modelling complexes.

At this time Gazprom VNIIGAZ LLC, under the supervision of Gazprom PJSC department (V.Kh. Herzog), has been conducting, on the base of Gazprom Transgaz Tomsk LLC, a research work titled 'Development and Implementation of Operation Algorithms for Natural Gas Flows Balancing Model in Gazprom Transgaz Tomsk LLC taking into account accuracy level of gas flow metering units and methods of gas quantity and quality parameters measurement, aimed at LCMN detection and reduction' using gas transmission network modelling complex.

Upon completion of R&D and algorithm performance tests, Company Standard «Operation Algorithm for Natural Gas Flows Balancing Model. Appraisal of the impact of metrological support level of natural gas quantity and quality parameters measurement on LCMN reduction index in the facility gas transmission system», the standard will be officially accepted and then the developed approaches will be applied to gas transmission companies of Gazprom Group.

## Development and introduction of a subsystem for detection of emergency situations

*I.R. Bukhvalov, S.V. Evseev, V.N. Lotov (Branch of the VNIIEF Yu.E. Sedakov NIIIS), V.A. Batrasov, A.I. Gurin (Gazprom Transgaz Nizhny Novgorod LLC)*

One of the most difficult tasks of the decision support system in dispatching control is the detection in real time of abnormal events on the linear part of the multi-string main gas pipeline (MMG), such as the rupture of MG and unauthorized rearrangement of valves. To solve this problem, linear telemechanics systems are used, which do not give an unambiguous answer about the place and type of the abnormal event that occurred. In 2017, the Branch of the VNIIEF Yu.E. Sedakov NIIIS developed a subsystem for detecting abnormal events based on the telemechanics of UNK TM. In 2020, in accordance with the «Roadmap ...» approved by A.B. Miller, Chairman of the GAZPROM Management Board, D.V. Manturov, Minister of Industry and Trade of the Russian Federation, and G.S. Nikitin, Governor of the Nizhny Novgorod Region, work was started on the «Organization of adaptation and implementation of the subsystem for detecting abnormal events (SDAE)» at the Gazprom PJSC facility. The first item of work was to conduct pilot tests of the SDAE at the Morkinsky Pipeline Directorate of Gazprom Transgaz Nizhny Novgorod LLC.

As a result of the pilot operation and a set of tests, all the technical requirements for the SDAE were confirmed, such as:

- the error in determining the location of the rupture of MG is not more than 200 m;
- determination of MG rupture when fixing the pressure drop of 0.06 kgf/cm$^2$;
- determination of abnormal rearrangement of valves when the pressure difference changes upstream and downstream the valve by 0.35 kgf/cm$^2$;
- no false reports of abnormal events;
- using only standard telemechanics hardware without the use of additional sensors and controllers.
- Based on the results of the pilot operation and acceptance tests of the SDAE at the Morkinsky Pipeline Directorate of Gazprom Transgaz Nizhny Novgorod LLC, the commission made the following decisions:
- recommend to put the SDAE of the Morkinsky Pipeline Directorate into commercial operation;
- recommend the use of SDAE of the Pipeline Directorate at the telemechanics facilities of Gazprom PJSC.

## Experience in developing a programming computing suite for modeling two-phase flow of a multicomponent mixture for the conditions of the Chayandinsky OGC field

*V.V. Samsonova, S.K. Mitichkin, V.A. Marishkin, V.I. Tchurin*
*(National University of Oil and Gas "Gubkin University", Gazprom Dobycha Noyabrsk LLC)*

One of the tasks being solved within the framework of the implementation of the import substitution policy in the Russian Federation is the development of Russian software for the dispatch decision support system, the key element of which is the complexes of modeling technological modes of extraction, collection, preparation and transport of natural gas, allowing to take into account the peculiarities of mining, geological and technological conditions of operation of deposits:

- component gas composition,
- two-phase state of the extracted mixture and phase transitions;
- the profile of the route, taking into account the complexity of the terrain;
- low temperatures and the effect of temperature on the operation of process equipment;
- gas speed control of the collection system;
- monitoring of permissible gas flow rates at wells;
- control of the working pressure of process equipment.

Specialists of Gubkin Russian State University of Oil and Gas together with Gazprom Dobycha Noyabrsk LLC for the conditions of the Chayandinsky OGCF have developed new and expanded the existing functions of the Vesta-Simulator (production) SCP, designed to simulate the operating modes of gas collection and preparation systems for trunk transport and including the following technological facilities: wells, well bushes, field pipeline gas collector, inter-field gas collector, pre- and complex gas treatment units, booster compressor stations. Vesta-Simulator (production) SCP is supplemented with a module for calculating the phase behavior and characteristics of the mixture in accordance with the Peng-Robinson equation of state, the calculation of the low-temperature gas separation process is implemented, and the operation of the helium concentrate membrane separation unit is described.

The package allows calculations of the «Wells – GSS – CGTP – BS – MG» system to determine the mode of operation of the field, ensuring compliance with the quality and specified plan for gas production, as well as determining the maximum allowable gas pressure at the border of gas transmission to the main gas pipeline.

## Development of comprehensive technical solutions for operational dispatch control systems of gas industry enterprises: sophisticated domestic approaches

*S.V. Varakin (Sirius Soft LLC)*

The development and introduction of domestic automated control systems is a primary task that ensures the safety and technological independence of the gas supply system. At the same time, safety is the exclusion of erroneous actions of operators, which can potentially lead to incidents and accidents.

The main tool should be processing the entire array of information coming from the managed facility.

The Sirius-Center software package includes software modules that facilitate the construction of complex fault-tolerant analytical systems to support dispatcher decision-making:

- an object-oriented model allows making descriptions of enterprise facilities in various sections (facility structure, relationships between facilities, subordination, etc.);
- the core – system services that form a single point of entry of information about enterprise facilities (maintenance of meta models, object models, calculation models, data analysis modules);
- a specialized data processing center is a fault-tolerant distributed computing cluster capable of simultaneously executing a large number of data processing algorithms available in the system and arriving in real time.

The history of parameter measurement, which is stored in the Sirius-Center system, is the basis for establishing algorithmic models. The mathematical apparatus of self-learning artificial neural networks is also used in the formation of models. Trained models are used to predict the service life of equipment, as well as the periods during which accidents and incidents may occur if preventive maintenance is not carried out and (or) equipment is not replaced.

In addition to the data processing algorithms, the computing core is planned to be equipped with a new module – a logical output machine. The main difference between logical output machine and an algorithm is the ability to automatically search for a solution based on the rules embedded in the machine. The rules are the regulatory and reference documentation for the operation of the APCS, on the basis of which the dispatcher works. The rules are entered into the logical output machine in the form of program code. At the same time, the logical output machine works as an assistant to the dispatcher and a situational analyzer, prompting the dispatcher to control actions, analyzing calculation data and the current state of the APCS.

## Volna PCS as a dispatch decision-making tool. Non-stationary calculation of compressor shop's equipment operation

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The Volna software and computing package (SCP) is designed for real-time operation as part of the dispatching control and management system of the gas transportation company and is used to support dispatching decisions. The Volna SCP provides a solution to the tasks of dispatching control of the gas transportation system (GTS): control of the current mode of operation of the GTS; operational forecast of the process according to a given scenario of the dispatcher's control actions; long-term planning of gas transportation modes; training of dispatching personnel. The package has been put into commercial operation at Gazprom Transgaz Ukhta LLC.

Currently, research is underway to further improve the Volna SCP in order to develop and include in the package a hydraulic model of the compressor shop (CS), taking into account the process pipelines of the CS. As a result of the research, a mathematical model, methods and algorithms of the hydraulic model of the CS were developed. The formulated algorithms are implemented as additional software modules integrated into the Volna SCP. Calculation schemes of the CS are introduced. Test calculations of the operating modes of the CS were carried out.

The developed hydraulic model of the CS is based on the joint calculation of the hydraulics of gas flows in the process gas pipelines of the CS and the operating modes of gas pumping units (GPU), dust collectors (DC) and gas air coolers (GAC). Calculations of the CS are carried out on the basis of individual technological schemes of the CS, taking into account the actual position of the shut-off valves, as well as gas pressure and temperature measurement data at the reference points of the CS. The areas of permissible modes and operating points of GPU, DC and GAC are calculated. The actual and calculated parameters of the mode are displayed on the CS calculation scheme and graphs.

At the final stage of the research, the adaptation of the improved Volna package will be carried out for online calculations of the operating modes of all GTS compressor shops of Gazprom Transgaz Ukhta LLC.

## Development of Astra-gas and other programming and computing suites at PJSC Gazprom: current and future challenges

*S.V. Komissarov (Gazprom inform LLC)*

Software packages of regime and technological calculations (hereinafter, the SCPs) are an integral part of Dispatching Management both at the level of subsidiaries and at the level of the Administration of Gazprom PJSC. In addition, SCPs are used in the design of gas supply systems, as well as part of training simulator units.

The Astra-gaz SCP has been widely used in the Gazprom Group of companies since 2008. Currently, daily and hourly calculations are carried out on an ongoing basis for 20 gas transportation subsidiaries and Gazprom Dobycha Noyabrsk LLC, and implementation is underway in Gazprom Dobycha Urengoy LLC. The Astra-gaz SCP is a part of the subsystem of Modeling and decision support of the Modernized Automated Dispatching Control System of the Unified Gas Supply System of Gazprom PJSC.

Developers and specialists of the Gazprom Inform LLC support service ensure the operability and development of the package, as well as monitoring the correctness of automatically performed identification calculations. The transfer of calculation results to the Department of Gazprom PJSC (S.N. Pankratov) and the formation of a retrospective database of calculations are constantly monitored.

One of the urgent tasks of the development of SCP is the calculation of the caloric content of the gas flow based on the known properties of the gas at inlet of the gas supply system, or by the component composition of the gas, taking into account the mixing of flows and intermediate measurements. Currently, this functionality has been implemented by the developers of the Astra-gaz SCP, testing and implementation has been carried out in Gazprom Transgaz Yugorsk LLC with the transfer of the results to the Department of Gazprom PJSC (S.N. Pankratov), implementation is being carried out in 7 more gas transportation companies.

In 2021, the process of renovation of the calculation modules of the Astra-gaz SCP with translation into a modern programming language was started. Computational experiments have shown that the speed of the most resource-intensive mathematical calculations in the source language of the implementation of calculations (Fortran) and in the modern open language of mathematical calculations (Python), turned out to be almost identical, which, given the presence of various mathematical libraries, allows us to talk about the prospects of using Python to implement all calculation models of the Astra-gaz SCP on it.

During the renovation of the user interface of the Astra-gaz SCP, taking into account current trends in the development of IT technologies, it is advisable to switch to the use of a web-based solution for displaying calculation schemes and calculation results. At the same time, it is advisable to use a single platform for working with graphical schemes both for modeling complexes and for other Dispatching control tasks.

The software of the Automated Dispatch Control System should include unified mechanisms that provide interfaces for the interaction of typical components of the SCP with each other and with external systems, which will allow the SCP to be decomposed into a number of loosely coupled typical subsystems: information exchange, storage, editing schemes, user interface, calculation modules.

These solutions will make it possible, in addition to improving the efficiency of the existing and implemented models of the Astra-gaz SCP, to ensure the introduction of calculation models of non-stationary modes of operation of gas supply systems in the gas transmission companies of Gazprom PJSC, as well as in the Department of Gazprom PJSC (S.N. Pankratov) integrated with the models of the Astra-gaz SCP and other information subsystems.

The further transition to the SCP microservice architecture will ensure the use of existing and new models in new decision support tools created as part of the Gazprom's Digital Transformation Strategy, including Digital counterparts of gas supply systems, as well as combined solutions of classical computational algorithms with machine learning and forecasting methods, including the use of neural networks.

## Volna programming and computing suite: user experience at Gazprom transgaz Tomsk LLC

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The Volna software and computing package (SCP) is designed for operation as part of operational dispatch control systems and dispatch decision support systems of the gas transportation company.

Since the beginning of 2018, Gazprom Transgaz Tomsk LLC has put the package into commercial operation.

With the use of Volna SCP the following tasks solved successfully:

- on-line modeling of non-stationary modes of GTS operation, the calculation results are in good agreement with the actual data of the SCADA system measurements;
- modeling of forecast indicators of gas transport systems' operating modes including taking into account the production of gas from the sites before bleed, repair work, launching pigs; start and stop of compressor stations. Based on the calculations, the optimal scenario is selected, which is implemented in practice;
- modeling of possible emergency situations with a gas pipeline rupture on the basis of on-line calculations during emergency training production dispatcher service;
- modeling of forecast of gas pipelines' primary filling, taking into account the critical modes of gas flow in by-passes and flares.

The functions implemented in the package significantly reduce the time spent on making dispatching decisions.

## Digital Production Facility Monitoring System (PFMS) platform as a tool of improved oil and gas project management

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The paper reviews the functionality of the Production Facility Monitoring System (PFMS), which was collaboratively developed by Gazprom EP International B.V. and Technos-K. The system is a digital platform that enables one-stop collection, structuralization and use of all engineering data generated throughout the life cycle of a well. It provides unified access to historical production data for all the participants in an oil and gas project in accordance with the role model and makes it possible to conduct a retrospective data array based analysis in order to enable more efficient management decisions. The paper describes the system's modules, such as the project, actual and analytical modules, which underlay the continuous workflow optimization cycle. It also reviews the existing well construction and production blocks, which involve the use of the above-mentioned modules. Access to relevant consolidated data, document management and analytics that are embedded in the system will thereby make it possible for the project participants to shorten the time spent on doing routine operations, thus allowing time to address more difficult issues and enabling quality improvements.

## Development, introduction and debugging of the monitoring system for the integral energy efficiency parameter of centrifugal superchargers at gas compressor units

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The paper describes the stages in creating and checking the system used to monitor the technical condition of centrifugal superchargers (CSC) at gas-compressor units (GCU). Monitoring the technical condition of gas-compressor equipment enables the controller to make decisions depending on the de facto energy efficiency of this equipment.

GCU CSC energy efficiency is a specific integral index that does not vary with changes in the GCU mode of operation or gas parameters across the gas transmission network.

The paper presents interim results of the monitoring of the GCU CSC energy efficiency index, provides their analysis and describes the actions taken in order to improve credibility of the GCU CSC energy efficiency index.

## Automation of gas pumping unit's performance control

*V.V. Zubaley (Gazprom transgaz Yugorsk LLC)*

A necessary condition for effective operational dispatch management is to ensure operational control of the GTS operating mode, primarily the GPU, the efficiency of fuel gas consumption. The analysis and control of the modes of operation of the GPU is carried out by the production dispatcher service together with the dispatcher departments of the divisions using the Magistral AIS SP, developed by the production dispatcher service of the enterprise jointly with Gazprom VNIIGAZ LLC and RTSoft.

To assess the efficiency of fuel and energy consumption, specific energy efficiency indicators of the gas pumping unit, compressor shop and compressor station are used.

As local indicators of energy efficiency, efficacy the load factor of the GPU for power, coefficients of technical condition for fuel gas, operating coefficient of centrifugal supercharger, the specific consumption of electricity for cooling the transported gas and other indicators are used.

Efficiency control is carried out on the basis of calculation of actual indicators and analysis of the operating mode of the GTU, current and preset energy efficiency at the level of the branch and administration: gas pumping units, compressor shops; compressor stations; gas transmission system as a whole.

The control process is carried out continuously or selectively, continuous control is carried out by the centers of responsibility – the Linear Pipeline Directorate of the enterprise, on an ongoing basis.

In order to implement the process of continuous monitoring of the efficiency of technological processes during the transportation of natural gas, a monitoring system is needed that allows automating control processes based on the processing of initial information from measuring instruments.

The monitoring system allows you to constantly monitor the performance of the main equipment operating mode targets, timely detect deviations from the set operating mode of the equipment and make decisions aimed at reducing energy consumption.

Magistral AIS SP solves the functional tasks of the production dispatcher service for monitoring, evaluating and analyzing the efficiency of operation of GTS facilities (GPU, horizontal air cooler unit, MPP, GCS, boiler houses), based on regular measurements of technological parameters. A modular approach to the construction of a system for monitoring the energy efficiency of technological processes has been implemented in the development.

The software package consists of the following modules:

- module «Energy efficiency of CS, aux PP, boiler houses, GCS, GCP»;
- module «Energy efficiency of GPU, parametric diagnostics and calculation of regime-energy parameters of GPU»;
- module «Ecologist-GPU» – control of gross emissions of pollutants with combustion products of GPU;
- module of administration of the software package;
- module for the formation of accounting documentation.

Project objectives:

- ensuring effective control and management of the technological process, taking into account the actual condition of the equipment, improving the efficiency of the GPU and GTS as a whole;
- increasing the utilization rate of GPU, reducing the likelihood of sudden failures;
- ensuring the process of processing and providing the necessary information about the actual condition of the GPU fleet and about the characteristics of units and equipment in operation (ensuring prompt access to information);
- ensuring the transition from the traditional system of scheduled preventive repairs to the repair of equipment according to the actual condition, reducing repair costs, improving the quality of repairs;
- increasing the stability of the values of the output performance indicators of the GPU (available power and efficiency) during the overhaul period by taking timely measures to eliminate the identified malfunctions on the working GPU;
- providing monitoring of energy consumption at GPU facilities, performance indicators of the operating modes of the main and auxiliary equipment at the CS in order to reduce energy consumption;
- ensuring control of the performance and energy consumption of GTS facilities – timely identification of system elements that affect the growth of total fuel costs for gas pumping (development of measures, optimization of the operating mode of GTS elements in order to reduce energy consumption);
- building a unified information system for monitoring energy efficiency at the enterprise using modern information technologies;
- control of gross emissions of pollutants from combustion products of gas turbine gas pumping units.

Results of operation of the Magistral SP:

- increase productivity and reduce overall operating costs of the enterprise;
- automation of the process of calculating energy and environmental indicators of the operating modes of the main and auxiliary equipment at the CS;
- performing a comprehensive assessment of the technical condition of the equipment;
- improving the accuracy of determining the performance and potential work of GPU compression;
- ensuring operational control of the limit parameters of the GPU;
- ensuring operational control of HPU loading by capacity;
- ensuring operational control of the loading and efficiency of air cooling units;
- providing operational personnel and management with key data on the operation of the equipment;
- reduction of the error of transmitted data on the operating mode of the equipment;
- reducing the time spent on data processing and analysis, ensuring the efficiency of information.
- reduction of energy costs for gas transportation.

The calculation modules of Magistral SP are unified and represent an easily expandable, flexible system that allows the user to control the calculation part and to sample any data from databases; thus, the user can conduct a continuous or selective analysis of the operating mode of the equipment in any required volume in a minimum time.

Software modules provide information interaction with databases from different manufacturers – Microsoft SQL server and Oracle.

The entire calculation part is performed on a server with free resources, which dramatically (at times) increases the speed of calculation processes; this is especially important with a large amount of information – for example, the calculation for a month, quarter, year. Quick-action is achieved due to the minimum amount of data when exchanging data over a local network between the client and server parts of the system – the server always has much greater computing performance than users' computers.

Magistral SP does not require installation of additional equipment, PC configuration is carried out at the user's workplace. Magistral SP is equipped with a user-friendly interface. The design of the package meets modern requirements and is designed for continuous work with a screen form that does not irritate eyes.

# PANEL C
# ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN DISPATCH CONTROL OF GAS SUPPLY SYSTEMS

## Modeling, optimization and management of the operation modes of the Unified Gas Supply System of Russia with the use of artificial intelligence technologies

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Dispatching control of the Unified Gas Supply System (UGS) of Russia requires advanced modeling tools and optimization of its operation modes. Gazprom Group has developed several software and computing packages (SCPs) for modeling and optimizing gas flows in gas transportation systems (GTS) and UGS in general, which are used in the practice of dispatching control of gas supply systems.

At the same time, there are a number of tasks that have not yet been solved. These include, first of all, the tasks of planning hydraulic modes of the UGS GTS according to various non-linear criteria, such as minimum consumption of fuel and energy resources for gas transportation work, minimum cost costs for gas transportation, etc. Such computational problems have nonlinear criteria and limitations in the form of equalities and inequalities, have a high dimension, and their solution requires the involvement of effective methods of mathematical programming. The lack of models that would allow us to adequately calculate the optimal operating modes of the UGS as a whole, while taking into account significant technological and physical nuances, requires further development of methods, algorithms and corresponding software systems.

In recent years, due to the intensive development of digital modeling and machine learning technologies, it has become possible to use new approaches to solving optimization problems of dispatching control of gas supply systems. In particular, artificial intelligence (AI) technologies provide tools for constructing adequate models of large fragments of the UGS GTS and the UGS as a whole.

The paper discusses new approaches to the modeling of UGS based on the AI technologies. The results of the conducted research on the construction of neural network models for predicting the dynamics of gas flows in the UGS GTS are presented The results of the development of a quasi-stationary hydraulic neural network optimization model of the UGS GTS are discussed. The first results of establishment of a non-stationary optimization model of the UGS GTS developed using advanced AI technologies, modern software packages of deep machine learning and nonlinear programming, are demonstrated. The developed technologies are part of the international standard ISO/IEC TR 24030:2021 «Information Technology – Artificial Intelligence – AI) – Use Cases» (section of the standard «Assistant dispatcher of a large energy system based on artificial intelligence technologies»).

The results of the work carried out indicate that the further development of hybrid modeling, combining classical methods of gas dynamics and AI methods, will allow creating new digital tools for proactive dispatching control of the modes of operation of the UGS, as well as solving a number of previously unsolved urgent computational problems of the gas industry.

## A machine learning method for detecting defects and pipeline features obtained using magnetic pig flaw detectors

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The paper considers examples of the results of machine learning algorithms in the processing of magnetograms of magnetic pig flaw detectors.

The quality metrics of the convolutional neural network for the detection and identification of defects, pipeline features and examples of the results of comparison with the markup of the data analyst of in-line inspection are given.

Statistically important parameters for solving the problem of detection and classification are given. The requirements for data completeness, the solution of the problem of unbalanced sampling by combining into classes of defects according to the identity of the signal signature and training a convolutional neural network model on «noisy markup» are considered. For the optimum of training of machine algorithms, suggestions are given regarding the approach to the marking of anomalous areas based on the results of analysis of a set of flaw patterns. Suggestions are given to improve the quality metrics of the convolutional neural network, taking into account the characteristic features of these magnetic pig flaw detectors.

The operability and applicability of machine algorithms in solving the problem of detecting and classifying types of defects and design features on the data of in-line inspection by magnetic pig flaw detectors is proved.

## Cyberphysical systems and educational process

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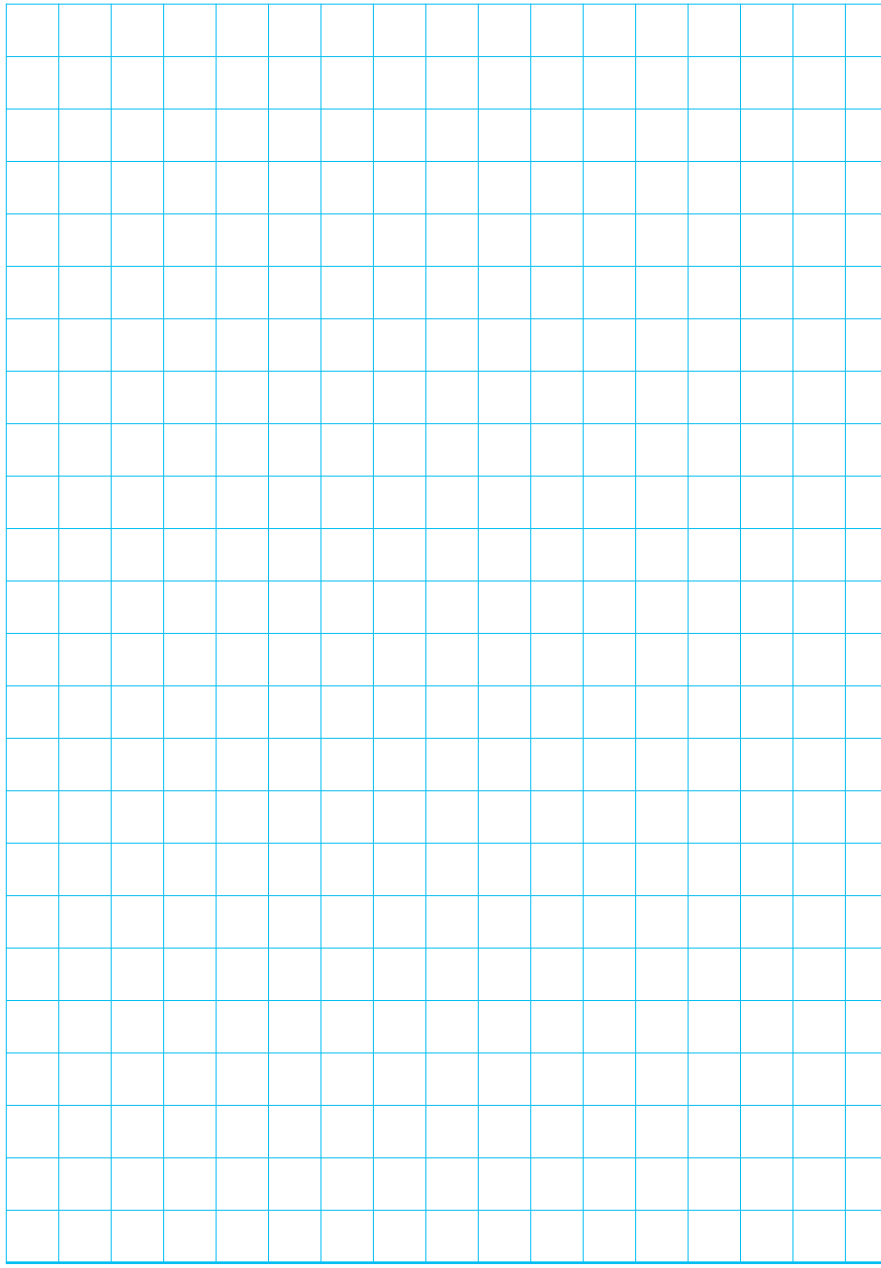
The products of the oil and gas industry remain a key source of energy for the industrial sector of the leading countries of the world. As the technological processes of the oil and gas industry become more complex, various approaches have been developed to intensify them and increase the efficiency of the design and operation stages. Industrial growth was accompanied by the development of information technologies, which, thanks to Moore's law, continue to develop intensively. The development of information technologies and their integration with the physical world is successfully reflected in the term «cyberphysical systems». The APCS is a cyber-physical system, where the control system is a cybernetic part, and the technological process is a physical one.

The report attempts to generalize the experience of solving applied problems of the oil and gas industry and teaching in an oil and gas university in the direction of «Management in technical systems». A systematic approach is proposed to study technological processes using mathematical modeling in order to synthesize control systems.

The level of safety and efficiency of operation of continuous processes depends on the level of understanding by operational personnel of the cause-and-effect relationships of the technological process. Consequently, the training of students at a higher educational institution should provide an understanding of the holistic picture of the technological process. Due to the complexity and danger of technological processes in the oil and gas industry, direct training on a real facility in a wide range of actions is not possible. In this case, the cyber-physical system should be included in the educational process. At the same time, the training program should be built taking into account the orientation towards communication with the cybernetic system within the framework of most disciplines, starting with junior courses. In this case, the appropriate style of thinking is instilled and the interrelation of the system components within the educational process is ensured.

Within the framework of modeling cyberphysical systems, it is proposed to study comprehensive approaches to modeling complex systems, to provide an understanding of the features of developing static and dynamic models taking into account the methods of calculating thermodynamic properties, to develop skills in using numerical methods for solving mathematical models, to apply simulation packages for the synthesis of process control systems.



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