METHODOLOGY OF SUBSTANTIATING REGIONAL GAS SUPPLY SYSTEM DEVELOPMENT AND PRACTICAL IMPLEMENTATION OF THIS METHODOLOGY

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ABSTRACT

In order to prepare decisions on development of regional gas supply systems models were developed as are aimed at identification of the current status of the system, optimal choice of project and reconstructed objects parameters, assessment of reliability of supply to consumers, assessment of technological risks of the project, operating objects and other aims.

Models are run in the frames of programming and computing (computer) system constructed according to the principles of system analysis. Software products are integrated into the uniform information-computing system with centralized data storage and universal different-type data visualization modules. This work represents brief information on some programs integrated into the complex.

CONTENT

INTRODUCTION

Russia successfully implements program of further gas supply connection of new districts situated in the European part of the country and in West Siberia; first steps of ensuring full-scale gas supply of urban and rural settlements have been made in the East Siberia and Far East. JSC "Gazprom promgaz" develops General Schemes of gas supply and distribution in the Russian regions. Expected increase of domestic gas consumption and growing scale of operating network reconstruction and capital repairs made it necessary to develop a methodology to make decisions on development of regional systems of gas supply (RSGS). The paper briefly describes this methodology and software systems developed for its implementation.

This work develops principle conclusions of paper «Elaborating strategic frameworks for development of gas supply and gas distribution systems in the regions» [1].

SUBSTANTIATING REGIONAL GAS SUPPLY SYSTEM DEVELOPMENT

Regional gas supply systems include subsystems of natural gas mains transport and distribution. To support the decision-making on development and operation control mathematic and computer models have long been used and became necessary. Feasibility of the decisions to be taken depends on these models suitability for the objects considered [2, 3]. In order to make decisions on development of RSGS analysis (hydraulic calculations), optimization and reliability assessment models of supply to consumers are of greatest importance. They allow assessing the status of operating systems and their technical capabilities on the additional volumes of gas supply, comparing alternative variants of development, assessing reliability of gas supply to the region, etc.

JSC "Gazprom promgaz" models are run in the frames of unified programming and computing (computer) system. The complex is constructed upon the principles of system analysis that in this case are limited to the followingt:

- accounting of technological interrelations, i.e. necessity to consider any part of the unified gas supply system in the context of operational and technological unity of all facilities and subsystems.

- consideration of all organizational interrelations, that is necessity to keep the balance of respective interests of federal and local authorities, JSC "Gazprom", gas distribution organizations and other parties, when designing programs of development and reconstruction;

- adaptability, i.e. requirement to take into account all functions of constructed and reconstructed facilities over the whole life cycle period;

- multicriteriality, i.e. expediency of considering, besides economic indices, such factors as requirements of reliable consumer supply, environmental safety, industrial safety, as well as short-term and long-term political and social consequences of the decisions passed;

- Continuity, i.e. obligatory reckoning with past decisions, level and quality of preceding programs implementation.

The tasks to be solved in developing of a specific project include:

- ˜system analysis of factors influencing decision selection [3];

- ˜evaluation of the operating system technical capability to ensure additional gas deliveries to the region, district, settlement. This evaluation is made by performing multi-variant hydraulic computation for RSGS [1, 4];

- ˜assessment of reliability and safety of the gas supply and distribution systems that are operated or designed [5, 6, 7].

Reliability of expected gas consumption assessment is one of the most important tasks influencing the quality of the generated decisions [3]. This task is implemented together with local authorities and includes comprehensive analysis of the region economic and social development plans. Gas supply in this analysis is considered an element of the region energy supply. To ensure rational selection of parameters for reconstructed and constructed networks we must take into account not only expected annual consumption, but seasonal and daily variability of gas consumption as well.

An important step in designing adequate models is model parameters identification based on the analysis of actual modes and forecast of their prospect values [2]. The forecast of hydraulic friction and technical status of equipment values shall be made on the basis of retrospective analysis of typical modes of gas transport and distribution systems operation, adaptation of mathematic model to them [1].

In order to define "narrow" zones of RSGS it is necessary to either execute multi-variant modelling of the gas flow modes taking into account increased (as compared to maximum achieved) loads of the region consumers in the frames of their design capacities or develop methods and procedures to assess throughput rate of individual fragments or RSGS as a whole (upon the given minimum parameters of equipment operation) [1]. Due to the possible increase in gas consumption in all Russian regions, the modelling process requires not only considering development of the system of gas supply of certain region but increasing transit flows. In the process of the operating systems throughput rate defining of we consider neighbour regions' gas systems operation shared mode of of a set of.

In order to make choice of technical solution in development and reconstruction of RSGS the reliability of gas supply to the consumers is analyzed [7, 8]. In case of low reliability values and high risks of gas supply breaks, technical solutions are subject to adjustment in order to increase reliability of industrial safety, or alternative variant of development or reconstruction of the RSGS are developed.

To this effect, a unique document on ensuring system reliability of the gas transport – CTO Gazprom 2-2.1-512-2010 [9] – was developed and approved.

SOFTWARE USED FOR TASKS OF REGIONAL GAS SUPPLY SYSTEMS

Mathematic models aimed at supporting the decisions on reconstruction and development of RSGS, are implemented in the specialized program products. Software and information base of JSC "Gazprom promgaz" develops constantly. The range of considered tasks can be divided into three levels:

7. 1.   Flow problems using aggregated scheme of the unified gas transport system including:

   - gas flow identification,

   - gas flow optimization,

   - analysis of consumer gas supply system reliability;

8. Hydraulic computations of the regional gas supply systems, including:

   - model hydraulic parameters identification;

   - new and reconstructed RSGS facilities' parameters optimization;

   - assessment of gas mains' and whole gas transportation system's reliability;

9. Hydraulic computations of the regional gas distribution systems, including:

   - new and reconstructed gas distribution facilities parameters optimization;

   - assessment of technological hazards related to operating and designed gas distribution facilities.

Each level requires application of specific information, algorithmic support and software which, however, shall be connected to the general hierarchic complex. The next programs are developed and upgraded:

   - ˜   Software for solution of flow problems of the unified gas transportation system (UGTS)— "VEKTA – UGTS";

   - ˜   Software for evaluation and analysis of reliability of consumer gas supply via UGTS – "SINAGS";

   - ˜   Software for selection of major technical parameters and evaluation of reliability parameters of mains and distribution gas pipelines – "VTP & OPN MG";

   - ˜   Software for modeling and optimizing gas transport modes at the level of gas transporters - Computer Complex (CC) "VESTA";

   - ˜   Software for analysis and optimum design of gas distribution systems — «PC ARS»;

- ˜ Software for evaluating technological hazards of gas distribution facilities with application of GIS MapInfo.

The developed software products are successfully used in preparation of proposals on reconstruction and development. They are integrated into the uniform information-computing system with centralized data storage and universal visualization modules of different-type information.

Information support is based on the use of the database under the control of DBMS Oracle. Centralized data storage allows solving problems of different levels swiftly and effectively and diminishes possibility of mistakes in preparation of initial data.

General functions of the mentioned software are listed below.

VEKTA-UGTS complex the interface of which is represented at the fig.1, is aimed at the solution of UGTS aggregated scheme flow problems and ensures:

- defining of possibility to supply gas to the consumers from the given gas supply sources;

- assessment of load of gas transmission network (GTN) sectors for the stated route of gas supply, defining reserves and narrow areas of GTN;

- defining of the maximum possible gas supply volumes;

- visualization of initial data and report results in the flow scheme coordinated with cartographic data to base material.

Fig.1. VEKTA-UGTS complex user's interface

SINAGS software complex the interface of which is shown at the fig.2 is aimed at assessment and analysis of the gas supply reliability via the unified gas transport system. Model implemented by the complex forecasts all possible failures of the gas transport system. At this, throughput rate of calculation flow chart arches becomes a random value of discrete type which is characterized by distribution range. The complex ensures:

- gas flow optimization in the system of gas mains;

- design of distribution ranges for efficiency of gas mains system fragments (flow chart arches) depending on own failures and failures due to the system;

- definition of gas supply shortage (gas supply distribution ranges) to the consumers of the system;

- assessment of the reliability parameters for the gas mains pipes sectors and system consumers.

Fig.2. SINAGS complex user's interface

VTP & OPN MG program modules are integrated into the unified computation complex, interface of which is shown at the fig.3. Software is aimed at selection of major technical parameters and evaluation of reliability parameters of mains and distribution gas pipelines. It has next functions:

- computation of throughput rate of gas mains and distribution pipelines;

- choice of gas mains technological structure and pump station locations ensuring preset throughput rate;

- computation of reliability index of gas mains and distribution pipelines;

- computation of gas output losses (insufficient supply) distribution function due to equipment failures and dead time.

Fig. 3. VTP & OPN MG complex user's interface

DKM VESTA computer complex, interface of which is represented at the fig.4, ensures hydraulic computations of interregional gas transport systems and RSGS. Computer complex has next operation modes:

- solution of mode and technologic problems on the basis of stationary quasi-isothermal model of gas transport via GTN;

- interactive off-line modeling of non-stationary operation modes of gas transport via GTN at the set dynamics of flow parameters at entrances and exits of the system;

- solution of mode and technologic problems using on-line databases of telemetry systems, such as SCADA.

Fig. 4. DKM VESTA complex user's interface

PC ARS program complex, the interface of which is represented at fig.5. is used to solve the next problems:

- hydraulic computation of gas distribution systems on the basis of stationary, non-isothermal gas transport model;

- parameters (site diameters) optimization of gas distribution networks using modern packages on non-linear optimization;

- assessment of economic parameters characterizing costs of designed gas distribution system.

Fig. 5. PC ARS complex user's interface

Programming and computing suite aimed at assessment of gas distribution systems technologic risk, interface of which is represented at fig. 6, ensures:

- assessment of technologic risk during operation, design and reconstruction of gas distribution systems;

- implementation of algorithms according to risk assessment methodology for design of gas distribution systems;

- the work in interpretation modes under control of MapInfo geoinformation system.

Fig. 6. User's interface of the computer complex used for technologic risks of gas distribution systems.

The mentioned computer products are used successfully in preparation of proposals on development and reconstruction of concrete objects, in science and research works of JSC "Gazprom promgaz", in gas transport modes modeling at the sub-systems of the Unified gas supply system (Gazprom JSC operator) and in the Oil and Gas RSU named after I.M. Gubkin, in science researches and in professional trainings.

Today program products are intensely integrated into the uniform information-computing system with centralized data storage and universal different-type information visualization modules . Information support is based on the use of the database under the control of DBMS Oracle [10].

CONCLUSION

Making decisions on prospect development and reconstruction of regional gas supply systems presupposes mutually agreed system researches on the analysis of social and economic development of the RF regions, assessment of long-term demand for energy resources, assessment of technical possibility, multi-factor gas supply system development optimization, analysis of gas supply reliability. JSC "Gazprom promgaz" developed a methodological approach to solve tasks of optimal development and reconstruction of regional gas supply systems. The complex of respective models and algorithms is implemented in program developments that were widely used and are used now when preparing decisions on development of Russian regional gas supply systems.

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10. *Sukharev M.G., Belinsky A.V., Samoilov R.V, Tverskoy I.V.,* Copyright certificate on database registration registered in the Computer software list (certificate No.2007610796) and Database list (certificate No. 2007620087) – 2007,
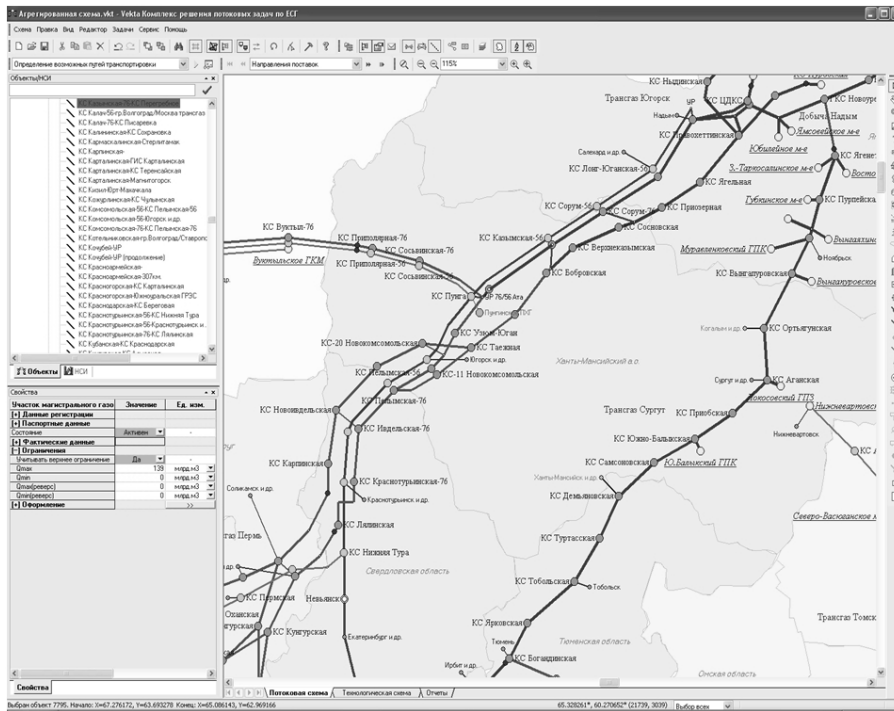
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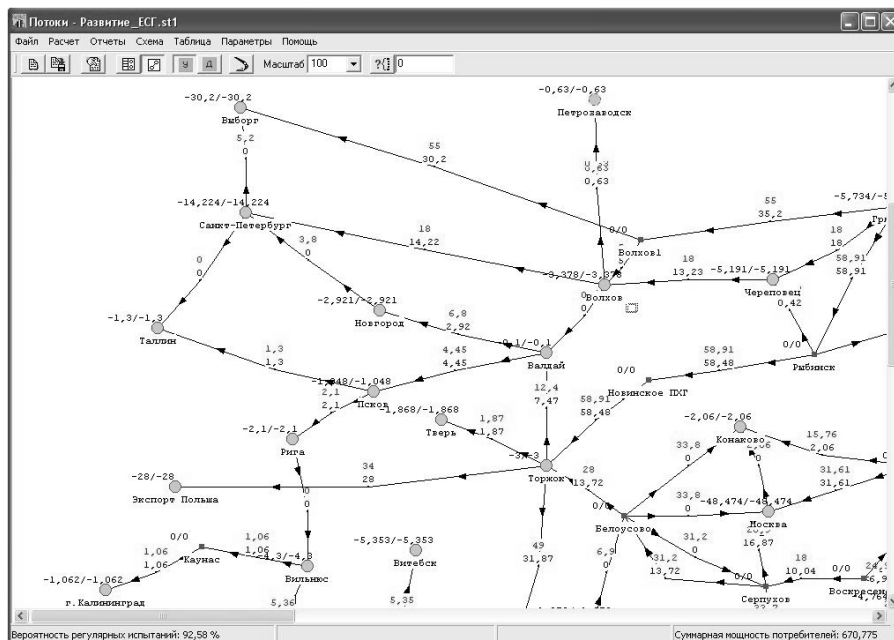Fig. 1. VEKTA-UGTS computer complex user's interface

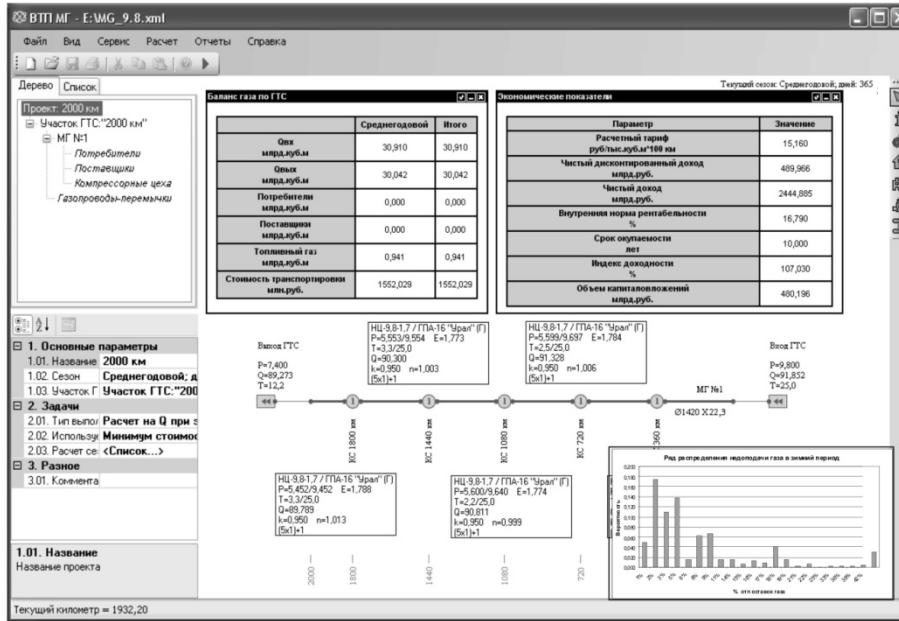

Fig.2. SINAGS complex user's interface

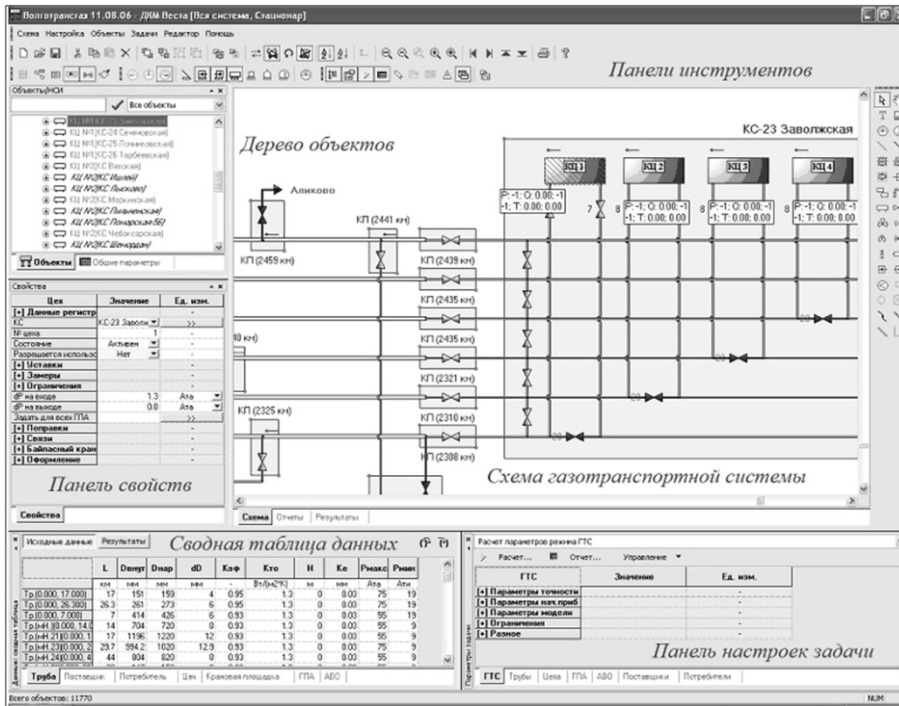Fig. 3. VTP & OPN MG complex user's interface

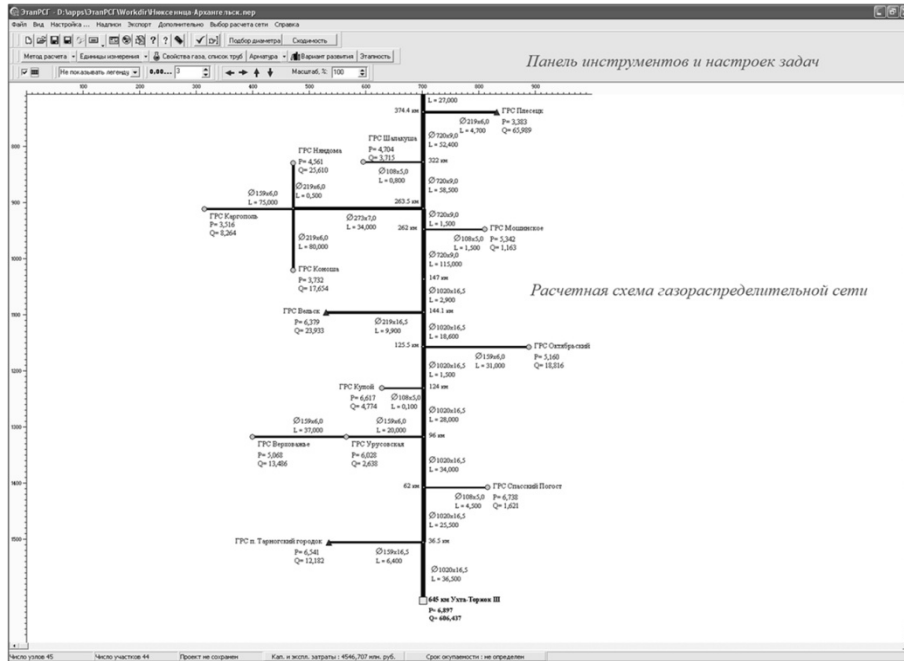
Fig. 4. VESTA-DKM complex user's interface
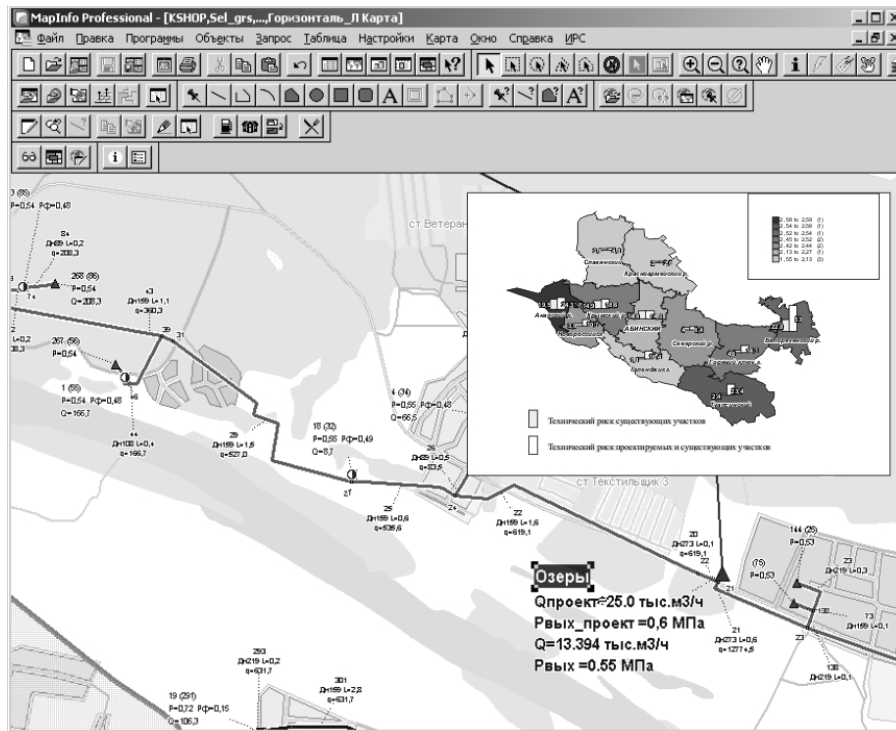
Fig. 5. PC ARS complex user's interface

Fig. 6. User's interface of the computer complex used for technologic risks of gas distribution systems.