

MODERN PRINCIPLES OF FORMING AND DEVELOPING THE NATURAL GAS PIPELINE SET OF THE RUSSIAN FEDERATION

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The principles and basic concept are considered to carry out the expert system for facilitating the creation and assessment of various adequate scenarios for strategic development of gas industry in Russia.

Introduction

Under conditions of the gas industry's current state the design of the scheme of development and reconstruction of the Russia's Unified Gas Supply System is a very complicated and labor-consuming task [1]. Its most important component is the formation of the scheme of development and reconstruction of the gas transportation system (GTS). The solution of this task is always achieved with a constant cooperation of both different departments Gazprom and corresponding scientific research and design institutes [2]. It should be also postulated that all proposed solutions must be within the framework of the general energy strategy of Russia.

It is known that gas transportation is the most capital-intensive branch of the gas industry, it accounts for over 85 percent of the fixed capital cost. Because of gradual depletion of the existing natural gas fields and the necessity of developing new gas regions a substantial change in gas flows will inevitably take place in recent years, which will entail enormous financial investments [3-5]. In this case the now operational systems (especially from the Nadym-Pur-Taz region, NPTR) may become underloaded, although their operation could bring essential income. Under these conditions, errors in planning of gas transportation systems may lead to a significant unjustified growth of Gazprom's expenditures.

With the planned economy, for the formation of strategy of the gas industry development for a medium-term period, a prolonged visiting conference of specialists-experts used to be organized, whom on the basis of preliminary studies as a result of joint consultations and necessary calculations formed finished materials.

Under the current conditions such approach cannot be realized due to the change of both economy itself and input parameters, which determine the formation of this strategy. Let us examine these input parameters.

Firstly, at present it is understood that the number of the development scheme variants to be examined must be sufficiently large. It is caused by the following factors:

- the depletion of the base NPTR fields calls for searching different options of compensation for the decrease in production, such as priority development of the Yamal peninsula fields or the Shtokman GCF, an increase in the output independent producers (not being part of Gazprom's structure), further development of gas liquefaction and production on the shelf;

- high risks, connected with the unreliability of gas supplies by Central-Asian states and, as a result, possible reduction in the volumes of its import;

- complexities in interrelations with some states, through which the transit of gas is carried out, call for examining alternative directions of export supplies.

- until now there is no single approach to forecasting of gas consumption.

Accordingly, within the framework of limited financial possibilities it is necessary to examine a great number of variants of the scheme of development and reconstruction of the UGSS GTS, so that, after estimating the technical and economic indices of each of them to select the most acceptable under the existing conditions. Furthermore, an increase in the number of variants is explained by the fact that Gazprom became one of the largest energy giants in the world. In the strategy of development of such companies an active part should take governmental bodies. Accordingly, in line with the general energy strategy of Russia the basic trends of Gazprom's development are formed with amalgamated plural decisions. Therefore the formation of the variants of the scheme of development and reconstruction of the UGSS GTS is going on under conditions of incomplete certainty, that, in turn, results in the necessity of a multivariant solution of this problem.

From the said above it is clear that the use of visiting conferences as a tool for the formation of the gas transportation system development would result in their inadmissibly long duration.

Secondly, the existing market relations between the scientific and production organizations, the required observance of the commercial secret law, the presence of

long-term strategic and short-term tactical interests result in the fact that the transfer of necessary information between participants of the scheme development takes an extremely long time and, therefore, delays the fulfillment of entire work.

According to the cited preconditions, it seems expedient to formulate main principles of creation of interactive system for the formation of the scheme of development and reconstruction of the UGSS GTS. These principles, naturally, should be based as on the analysis and subsequent generalization of nowadays existing approaches, and on the development of new ones, linked with capabilities of modern information systems.

The present work is aimed at modernization of the rules, which have been developed to the present time, of the solution of this problem with the purpose of creation of a uniform interactive expert system including a program complex, using a unified database with attraction of expert groups of specialists in respective problems.

Development stages of the master plan

It is proposed to carry out the process of the master plan development in two stages:

- at the first stage the system approach to the formation of the master plan of development and reconstruction of the UGSS GTS (Fig.1) is used;
- at the second stage basic technical solutions at a level of separate sections of the UGSS GTS (Fig.2) are formed.

It should be noted, that carrying out of calculations and decision-making should be based on approved methodical provisions. Accordingly, it is necessary to conduct analysis and systemization of existing techniques and methodical instructions with the purpose of their subsequent use in applied algorithms and programs. Besides, because of great volume of the information obtained as a result of calculations, for the work of groups of specialists the development of expert systems based on the up-to-date computer technologies will be required. It will essentially accelerate the search of necessary solutions and will allow specialists-experts to make more operatively adequate decisions. Thus, the development of such expert systems should be conducted with direct participation of experts subject to the specific task. In the presented Fig.1 and Fig.2 problems where expert systems are used, are set off in bold frame. Proceeding

from the aforesaid, for simplification of the work of experts and faster decision-making the creation and coordination of target forms is expedient. It will simplify the perception of the information obtained as a result of calculations, both at intermediate stages, and in the final document of the master plan of the gas industry development. For accentuation of attention in Fig.3 the considered three subtasks are separately set off.

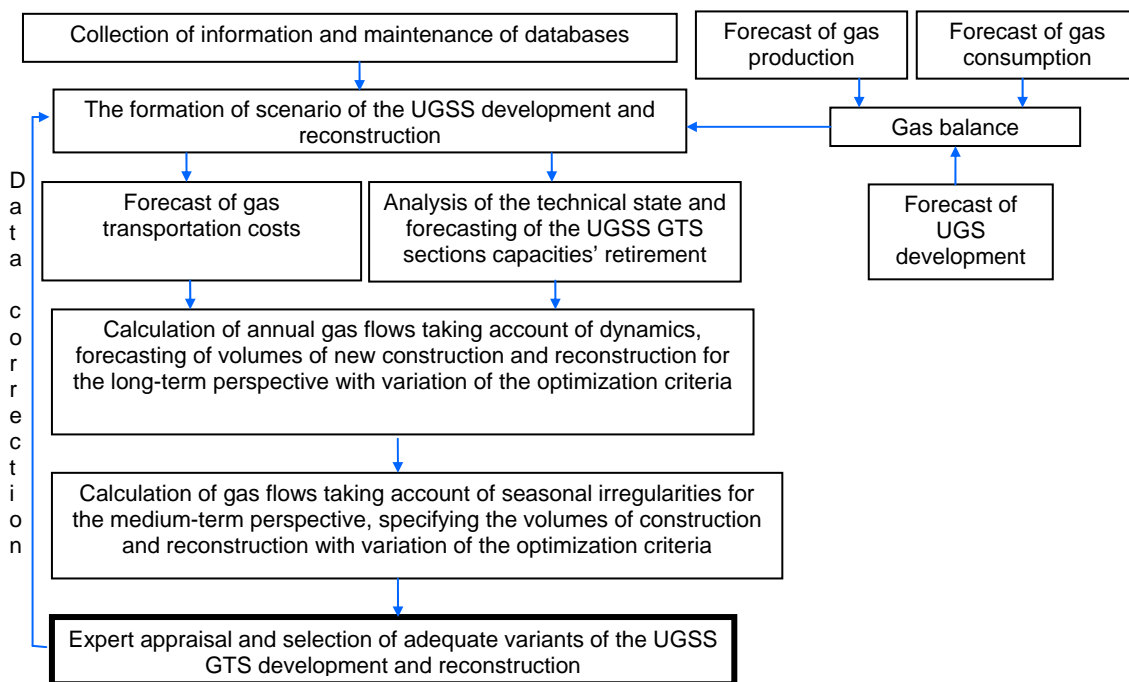


Figure 1. The formation of the master plan of the UGSS GTS development and reconstruction. The system approach to the formation of the master plan of the UGSS GTS development and reconstruction

Without dwelling in detail on each of subtasks (Fig.1, 2), we shall consider the basic approaches to their realization.

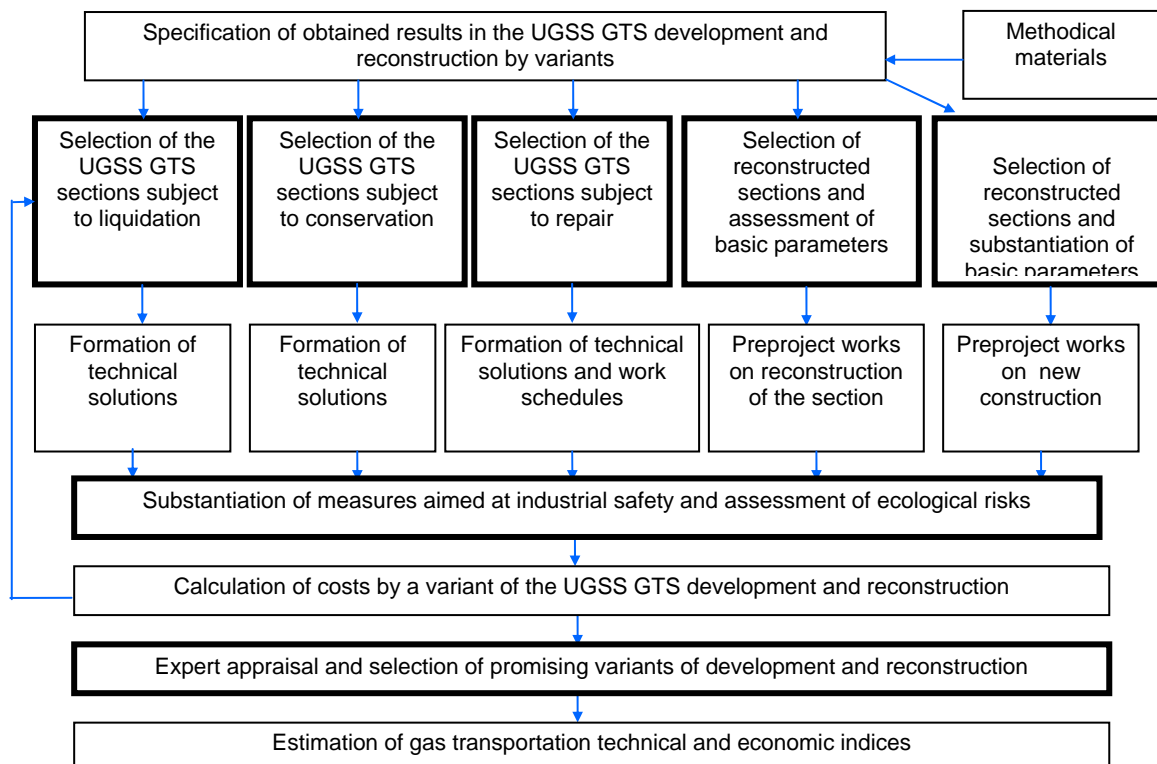


Figure 2. The formation of the master plan of development and reconstruction at the level of the UGSS GTS sections

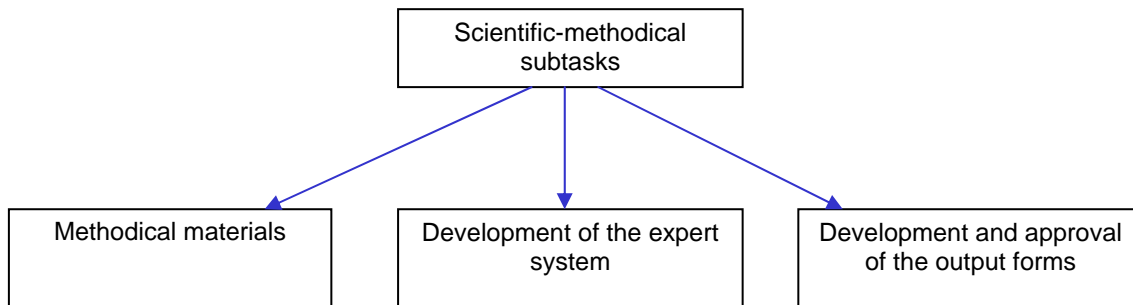


Figure 3. The required scientific-methodical support in the creation of the interactive system of the formation of the master plan of development and reconstruction of the GTS UGSS

Stage 1. The system approach to the formation of the master plan of development and reconstruction of the UGSS GTS

Collection of information, creation and maintenance of the databases

It should be separately emphasized that as a basis in the formation of the master plan of development and reconstruction of the UGSS it is expedient to accept the upper

level GTS scheme used in Gazprom's Central Production Control Department (CPCD). The fact is that the aggregated flows diagram, used at present in the perspective middle- and long-term planning, in its time was accepted in a very amalgamated form because of insufficient capabilities of computer technology at that time. Accordingly, the gas production and consumption were linked to the knots of this amalgamated scheme. At present such problems practically do not exist. Besides, in CPCD the gas flows scheme has been tested in practice, its adequacy is not questioned, since it is used in the daily operational work and, which is very important, it is integrated into the unified database "Infotekh". This allows using the ready and more complete data on the technical equipment of individual sections of UGSS gas pipelines. In turn, this approach will enable obtaining more adequate information at the stage of formation of the scheme of development and reconstruction at the level of the UGSS GTS sections (Fig. 2). This, in the first place, is related to the subtasks of selection of sections subject to liquidation, conservation, to repair, reconstruction, as well as for substantiation of measures for ensuring industrial and ecological safety. Of course, the application of the CPCD scheme will require significant efforts in the tying to the knots of the system of gas consumers and suppliers and, correspondingly, will complicate the formation of the gas balance. Nevertheless, the benefit from the shift to the CPCD scheme is obvious.

The formation of the scenario of the UGSS development and reconstruction

At present forecasts in the industry are made for the period up to 2030. It should be noted that the structure of the scheme would change with years due to emergence of new gas consumers and suppliers. Therefore, as the starting time stages for the long-term planning one should accept the now existing laying out: 2010, 2015, 2020, 2025 and 2030.

On the basis of the obtained forecast values the gas balance for the knots of the entire UGSS GTS system is formed, and, as was said before, the production and consumption are tied to the network units.

In accordance with the existing gas balance dynamics the working group of specialists forms scenarios of development reflecting the basic trends of the change in the gas industry. For the formed scenario a preliminary calculation of the forecasted values of expenditures for the gas transit (taking account of the component for capital

investments) and calculation of retirement of the UGSS GTS sections capacities are carried out. At that, the calculation of the volumes of the capacities retirement must be carried out under condition of passive expectant strategy without capital repair and reconstruction. These data are necessary for determining the criteria of optimization and limitations in the flow simulation of the gas transportation network.

Calculation of gas flows taking account of the gas balance dynamics

In order to avoid ineffective investments in the UGSS GTS development and reconstruction, the calculation of annual flows is conducted taking account of the gas balance dynamics. As the final optimization criterion it is proposed to use the minimum expenditures for gas transportation taking account of the capital investments component in (it seems expedient to use a concept of the net discounted income (NDI). This approach in general case will make the task nonlinear, therefore the iterative recalculation of expenditures for gas transportation and optimum gas flows will be required. In first approximation the optimization criterion should be the minimum of the product transportation work (PTW) or its modification - the product transportation work equivalent (PTWE). These calculations allow us to estimate the dynamics of the required productivity by the UGSS GTS sections. In the medium-term perspective the previously obtained results are specified in the calculation of gas flows taking into account the seasonal fluctuations of gas consumption.

Expert assessment and selection of adequate variants

In order to assess the effectiveness of variants preliminary calculations of the technical and economic indices of each of them are conducted. The selection of versions is carried out with use of a specially developed expert system.

Using the performance capabilities of the interactive system, experts in the dialogue regime form a certain set of adequate variants of the UGSS GTS development and reconstruction for subsequent adoption of technological solutions, calculation of economic indices, and making corresponding recommendations.

Stage 2. Examination the basic technical solutions at the level of separate sections of the UGSS GTS

At the second stage (Fig. 2) the issues of the UGSS GTS development and reconstruction at the level of separate sections are dealt with. It should be noted that at this stage as experts must be used specialists perfectly well understanding the gas transportation technology with the obligatory attraction of representatives from design institutes. For each of the selected at the first stage variants the experts examine the sections subject to liquidation, conservation, capital repair, reconstruction and new construction. For all these sections technological solutions are formed and preproject works are carried out.

For conducting repair works in the nearest future at the existing sections of gas pipelines it is necessary to develop their optimal timetable.

Assessment of ecological risk

The results obtained both at the first and second stages enable to examine aspects, connected with the industrial safety and assessment of ecological risk for each variant. When considering the variants one should returned to the integrated scheme of the UGSS GTS and estimate the damage from the emergencies with the purpose of assessment of ecological consequences and compensating capabilities of ecosystems located in the zones of impact.

The calculation of the ecological risk probability is usually conducted with use of the Monte Carlo method and is derived as a probability of negative ecological impacts, for example, loss of forests as $n \cdot 10^{-1}$ - $n \cdot 10^{-6}$ [6-7]. The assessment of the probability of the risk appearance is given to the developers of the scheme of the GTS development or to the managers of a concrete project with indication of the entire uncertainty connected with the assessment of ecological risk. Although the majority of projects in the UGSS GTS are directed not only toward the solution of ecological problems, but also to achievement of specific economic indices, the solution of emerging ecological problems must be envisaged in all these projects and taken into account in the accomplishment of the multivariant development of the UGSS GTS. Achievement of economic priorities is accompanied by an increase of ecological risk,

but this increase should be acceptable. The reduction of risk is an expensive procedure, especially, with its low values (Fig. 4). However, this prevents the undesirable ecological consequences of the works, conducted in the UGSS GTS sections [8, 9].

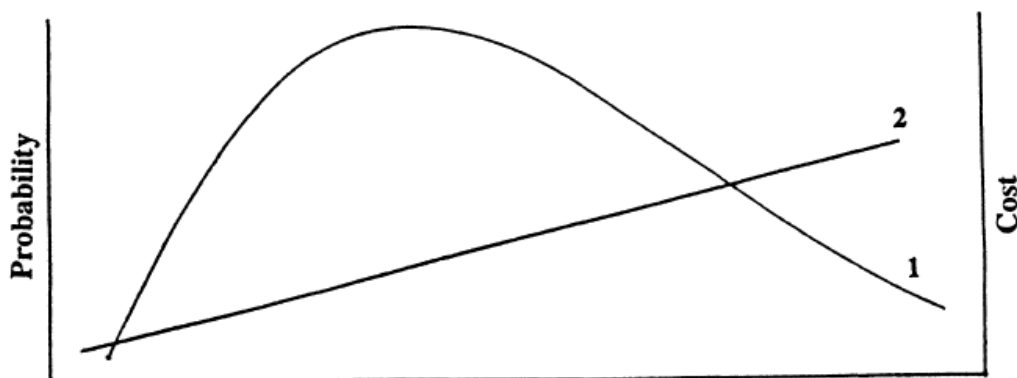


Figure 4. Diagram of the comparative analysis of a probable distribution of the values of the acidity critical loads on ecosystems and costs of reduction of emissions of compounds of nitrogen and sulfur:
 1 - functions of the probable distribution of the critical loads values
 2 - cost of the reduction of emissions

The less the value of ecological risk probability, the more expensive the measure for its reaching. It should be emphasized that the prevention of one risk may cause another one; the process of evaluating the risk is always connected with the selection from a specific number of alternative approaches.

Conclusion

The proposed principles of creating of interactive system allow the researcher to accelerate the process of decision making and the formation of adequate scenarios of development of gas industry in Russia. The formation of tasks is carried out by a working group of specialists, who by themselves coordinate tasks, the periods of their fulfillment, and the procedure of the works coordination.

The presented approach allows the managers to estimate the economic indices of each variant of the UGSS GTS development and reconstruction, and select those variants, which could be recommended for Gazprom.

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