DEVELOPMENT OF RECOMMENDATIONS FOR THE EFFECTIVE FUNCTIONING OF THE GAS SYSTEM OF KALININGRAD REGION

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Abstract:
Prolonged and intensive use of the gas transportation system of the Kaliningrad region, led to the deterioration of a number of areas. This article discusses the current state of the gas transmission system and possible options for its repair without interrupting the gas supply to the Kaliningrad region.

Key words: *infrastructure, transmission of gas, continuity of supply*

INTRODUCTION

The main types of natural resources which are used for industrial production, heat and power in the Kaliningrad region are coal, oil and gas [1]. Gas fuel is about 75% of the total amount of supplied energy. Kaliningrad area is energy-dependent region, about 99% of gas supplies in the region is going through the gas pipeline Minsk – Vilnius – Kaunas – Kaliningrad. The effective functioning of this pipe is a dependant of energy supply to hundreds of thousands of Kaliningradians and a lot of companies in the region. Consequently, delivery and stable supply of gas to the region by gas pipe is one of the most important tasks. Unfortunately over the past years of operation of this transmission system, it was largely deteriorated [5]. That is why it is necessary to ensure its maintenance without interrupting the supply of gas to Kaliningrad region.

GENERAL INFORMATION ON GAS TRANSPORTATION SYSTEM OF KALININGRAD REGION

Consider the gasification of the Kaliningrad region in terms of providing the region with natural gas. The overall level of gasification of the population in the region is 92.4%, but this figure included 43.7% of the population, only the gasified by liquefied gas. Only 48.7% of the population has access to natural gas [2].

Analyzing the level of gasification of industry in Kaliningrad region, it is important to note that natural gas is supplied to the following cities – Gvardeysk, Zelenogradsk, Kaliningrad, Krasnoznamensk, Neman, Pioneersk, Polessk, Svetlogorsk and Soviet. Several cities in the region remain without any natural gas supply (imported liquefied gas). In Chernyakhovsk, Gusev, Nesterov, Ozersk, Bagrationovsk, Mamonovo, Ladushkin, Baltisk, Primorsk gas cylinders are used in order to supply gas to enterprises and people.

There are several major gas consumers in this area. First of all, there are orb of objects – TEC-1, TEC-2, RTS South, RTS East, RTS Dune, etc. And of course several light industrial facilities – Soviet and Neman Pulp & Paper Mills, Kaliningrad meat and fish-canning factories, distilleries, poultry factories and more.

Additional gas pipe system construction is important and promising areas of development in Kaliningrad region. In general, the level of gasification of natural gas remains rather low in the region [6].

On the other hand, in the context of industrial production the most important factor is energy security.

Unfortunately, the Kaliningrad region is very dependent on gas, so it's need to develop an effective scheme of pipeline repair.

Because natural gas is the most cost-effective fuel for production, and one should take into account the fact that the Kaliningrad region is energy-dependent region. Gazprom company, that has started construction of storage facilities in the town of Romanov, should provide the energy security of the region in the event of termination of gas supply. In addition, it should serve to align the difference between summer and winter periods of gas consumption (through the accumulation of excess gas). Due to the fact that the gas pipeline was built in 1985, the number of corrosive elements has significantly increased over 25 years of system operation. There are elements with a high degree of wear and tear, etc. Therefore in 2009 and 2010, Gazprom Company conducted a study of flaw state of the inner cavity of the pipeline [1].

INVESTIGATION OF GAS TRANSPORTATION SYSTEM OF KALININGRAD REGION

The aim of this investigation is to identify the most damaged sections of Kaunas-Kaliningrad pipeline as well as the development of an optimal package of technologies for it repair without stopping gas pumping.

The state of the gas pipeline from the compressor station "Krasnoznamensk" to the gas distribution station "Svetlogorsk" was considered. The study showed that a

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coefficient of efficiency of gas system is about E = 0.93. Study proved that the average pressure throughout the pipeline is less than the estimated 4.72 MPa (with an estimated 5.3 MPa). It means that the Kaliningrad region looses about 40 thousand m3 of gas every year [4].

An analysis of the overall dynamics of wear on the basis of in-line inspection by electromagnetic and radiological studies has identified a number of areas affected by a high degree of corrosion wear (Table 1) [6].

<div align="right">*Table 1*</div>
Priority of repair of the pipeline, with a view of the used technology and the limitations on terms

The line repair	Group sites	The proposed technology of repair	Terms of repair
1	28, 93, 147, 148	Bypass, hot tapping	1-1,5 years
	170	FS-7OTGM	
2	64, 23, 25	Threaded hose	3 years
	94, 157, 66	FS-7OTGM	
3	161, 63, 15	Fiberglass	5 years
	171, 162, 121	FS-7OTGM	

There are four parts that are the most worn out due to internal corrosion: 28, 93, 147, 148 (the length of each segment – approximately 1km). These areas require immediate replacement, that can be done either by a full stop of the gas system, or by usage of bypass method, which is one of repair methods that do not require to reduce a supply of gas to the region [1].

Further sites were identified with very high levels of contamination in pipe by hydrates and paraffin's, which is caused, obviously, by inadequate cleaning and drying of gas before starting it in the pipe, and a high degree of corrosion in several areas. In our investigations we researched distribution of paraffin and other components by pipe walls. Taking into account that corrosion of pipe walls is usually related with chemical impact of paraffin and also cavitation

destruction by dust particles we have developed mathematical model of dependence loss of gas by pipe walls thinness. All this processes were shown on linear regression model.

Table 2 shows the two variables – the x and y, where x – the average depth of corrosion wear of the analyzed segment, and y – the average pressure on the analyzed segment.

Next, a series of calculations has found correlation coefficient. We present them in detail.

Based on data from above table, we construct a regression correlation dependence. Given that the basis of these data, correlation is linear, we use the following method to construct a regression correlation dependence. Value of r was calculated by the following formula [3]:

$$r = \frac{n \sum_1^n x_i y_i - \sum_1^n x_i \sum_1^n y_i}{\sqrt{\left[n \sum_1^n x_i^2 - (\sum_1^n x_i)^2\right]\left[n \sum_1^n y_i^2 - (\sum_1^n y_i)^2\right]}} \quad (1)$$

r = - 0.983

Next, we construct a graph showing the dependence of the two indicators and dynamics of their spread in the studied area. Based on these figures, it is obvious that the graph is linear. Therefore, we construct a graph based on the classical formula for the line:

$$Y = kx + b \quad (2)$$

Given that x – a random variable, and y – depends on x variable, we express k and b by x and y.

After substituting the values represented by the formula of the bottom row of Table 2, we obtain the following values:

b = 0.673; k = − 0.613; r = - 0.983;
In this case, the regression equation is as follows:

$$y = -0.61x + 0,67 \quad (3)$$

The linear regression equation was plotted on Fig. 1.

<div align="right">*Table 2*</div>
The summary table for the correlation regression analysis

| NN	1	2	3	4	5	6	7	8	9	10
Xi (depth of corrosion),mm	0.1	0.1	0.12	0.13	0.13	0.14	0.14	0.15	0.17	0.19
Yi, MPa	0.650	0.640	0.633	0.610	0.605	0.600	0.594	0.578	0.570	0.564
NN	11	12	13	14	15	16	17	18	19	20
Xi (depth of corrosion),mm	0.19	0.19	0.2	0.23	0.25	0.27	0.3	0.31	0.32	0.35
Yi, MPa	0.540	0.510	0.505	0.505	0.502	0.490	0.478	0.440	0.432	0.420
NN	21	22	23	24	25	26	27	28	29	30
Xi (depth of corrosion),mm	0.4	0.41	0.43	0.43	0.43	0.48	0.5	0.52	0.57	0.59
Yi, MPa	0.410	0.405	0.405	0.400	0.395	0.395	0.389	0.380	0.340	0.330
NN	31	32	33	34	35	Sum	Average sum			
Xi (depth of corrosion),mm	0.59	0.61	0.63	0.65	0.67	11.92	0.341			
Yi, MPa	0.310	0.307	0.302	0.300	0.295	16.226	0.464			
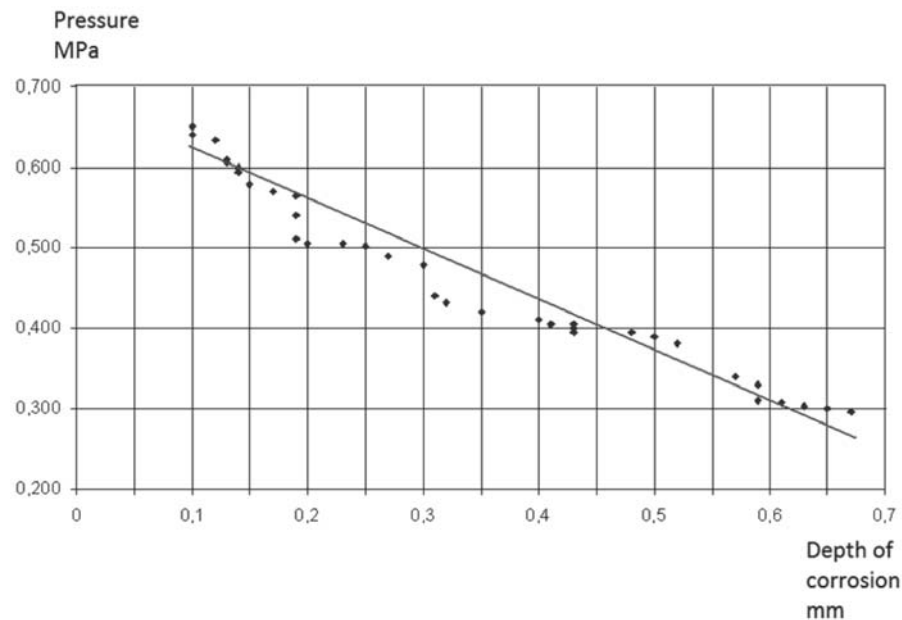
Fig. 1. Dependence of losses and reduce the volume of gas supply, on the depth of corrosion

In considering the repair pipeline, recognized as the most effective method for extending the life of the pipe cleaner through the probe FS-7OTGM, which allows you to remove the paraffin-tube and corrosion in repair zone.

CONCLUSIONS

As a result, research has established that it is necessary to repair sections 170, 94, 157, 66 using in-line probe. Repair of these areas should be made within the next eighteen months before the expiration of the remaining life.

In addition to sites identified in the first repair group, identified areas for the second and third repair lines. For sections 64, 23, 25 – we recommend a method of repair using flexible hoses and also for sections 161,63,15 the most preferable method of repairing is fiberglass.

As a result of research, practical conclusions and recommendations were developed. Practical hints were given by regression model which aims at pumping power losses and reducing the volume of gas supply, depending on the thickness of steel and corrosion.

In general, given the high degree of dependence of the Kaliningrad region from timely supply of gas, especially in the winter, one should consider it expedient to pay attention to Gazprom company and the need to diversify routes and modes of supply of gas to the region and to create a gas storage facilities in this area.

Also, we recommend that the regional government shall pay attention to accuracy and clarity of the gas supply by the Gazprom company, as well as the need to increase the supply of electricity to the region, both at the time of repair and replacement of pipes in the existing pipeline Kaunas-Kaliningrad, and in case of emergency breakdown of gas pipe system.

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