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THE RESEARCH OF QUALITATIVE INDICATORS OF GAS PIPELINES DURING THE OPERATION

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ABSTRACT

The operation of gas pipelines is a complex of technical measures, aimed at preservation of the main stock of gas pipeline transportation facilities. The purpose of these measures is to maintain and to restore the initial operational capabilities of gas pipelines, in general and in particular areas. The line section of gas pipelines has the largest size and cost.

Naturally determined process of changing the quality of gas pipelines during the operation is accompanied by the accumulation and development of damages, failures; this determines the objective need to restore the quality of operation. The practical running of the line section of gas pipelines is characterized by a certain flow of failures; therefore it is necessary to ensure the required level of reliability of the gas pipeline during the entire period of operation. The quality control study of the inter-settlement gas pipeline section was conducted, and graphs of dependence of gas pipeline quality parameters on time were presented in the work.

Keywords: line section of the gas pipeline, technological state, failures in operation, gas pipeline operation, control and quality parameters of the gas pipeline.

1. INTRODUCTION

The modern life of cities and settlements is impossible without gasification of residential and industrial buildings and structures. Determination of the operational lifetime, periodicity and type of repairs, unfailing performance, period of service and reliability of gas pipelines - is the main task of operating organizations.

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The operation of gas pipelines is a complex of technical measures, aimed at preserving the main stock of gas pipeline transportation facilities [1, 2]. The purpose of these measures is to maintain and to restore the initial operational capabilities of gas pipelines, in general and in particular areas. The line section of gas pipelines occupies the largest volume.

The initial level of gas pipelines quality is the constructive and technological potential, which the gas pipeline has at the start of the operation. The level of quality does not guarantee operability in the process of gas pipelines operation, since unfailing performance depends on the level and nature of the operational loads, compliance with the operating rules, and the organization of quality control of the gas pipeline operation [3, 4, 6]. Statistical design methods were used to evaluate the quality control of the inter-settlement gas pipeline, which allowed a qualitative assessment of the dependence of quality parameters on time. The use of this technique makes it possible to predict the deterioration of the pipeline elements in time, that, when taking timely measures for repair or dismantling, helps to prevent emergency situation on site.

2. METHODOLOGY OF THE RESEARCH

The project and executive documentation is the source material for the estimation of the technical state.

The application of methods of modern mathematical statistics opens the potential for revealing the objective regularities of the process under consideration. The use of these methods makes it possible to obtain maximum information with a minimum number of conducted experiments, and to evaluate the reliability of the obtained results [5, 7, 8].

The time of failure-free operation τ_s(time to failure) at a constant load$P_s$is determined with the help of the following expression:

$$\tau_s = b^a{}_2 \tau_t^{a2+1} / P_s^{a2} (a_2+1) \quad (1),$$

whereτ_s- is the time of failure-free operation, P_s- is the load for which the time of failure-free operation is determined, τ_t- is the average loading time for a constantly increasing load $P_t$till the failure, a_2, b - are the coefficients.

Failure (destruction) occurs at time t_H.

Lifetime under the load $P_H$is determined from the expression:

$$\tau_H = (tk_1 t_{H2} – tk_2 \, t_{H1}) / (tk_1 - tk_2) \quad (2),$$

whereτ_H- is the average lifetime under the load P_H, obtained by testing a several number of pipes, tk- is the average time to failure.

Then the estimation of mathematical expectation was carried out.

The probability of failure-free operation, depending on the change in length, due to recorded failures and preventive replacements [2]:

$$P(t,l) = (L_0(t)-\Sigma\Delta l_i(\Delta t))/ L_0(t) \quad (3),$$

where $L_0(t)$ - is the length of gas pipeline, $\Delta l_i(\Delta t)$ - is the change in the length during the operation period for a certain period of time, t - is the operating time.

The probability of failure-free operation, taking into account the length of the failed section with a fixed number of failures,is the following [8, 9, 11]:

$$P(t,l, n) = (L_0(t)- l_0\Sigma n)/ L_0(t) \quad (4),$$

where l_0- is the length of the failed section, m, n- is the number of failures during the time interval t.

The probability of failure-free operation, taking into account the average weighted length of the failed section with a fixed number of failures is calculated as follows [9, 10, 12]:

$$P(t,l_{cp}, n) = (L_0(t)- l_{cp}\Sigma n)/ L_0(t) \quad (5),$$

where l_{cp}- average weighted length of the section, m.

$$l_{cp}= \Sigma(l_i(\Delta t))/ n_i(\Delta t))/(t/ \Delta t) \quad (6),$$

where $n_i(\Delta t)$ - is the number of failures during the time interval.

3. RESULTS

Restoration of the quality of the gas pipeline line section during the operational period consists in preventing the failures through targeted organizational and technical influences, and contributing to the improvement of the reliability and durability of the pipeline. This task can be performed by means of transition from the required level of operational reliability (Pt), through the parameters of the pipeline failures flow, to the characteristic of restoration the quality of preservation of the gas pipeline line section of required quality – this is a complex of restoration and preventive measures for the entire set of working parameters of the gas pipeline (($\Sigma\omega_i$)- design position, insulation state of joints, quality of line accessories) [6, 7, 13].

The quality of each structural element, characterized by certain parameters, undergoes a functional change in the process of operation. Operational factors determine the process of reduction the level of quality to a certain value, at which the line section of the pipeline comes to a failure [10, 14, 15, 16].

The study was conducted on the inter-settlement gas pipeline, located near the settlement Akhmatov, Aleksandrov-Gay District, Saratov Region, with a population of 7,300 people. The diameter of the pipeline is 426x9 mm, and the length is 11 km.

The criteria for statistical analysis were the parameters, quantifying the actual state of the line section of pipeline.

The failures of the line section of pipeline were classified according to the following criteria:

- the place of demonstration (base metal of pipes ($\omega 1$), shop weld (ω_2), welding joint (ω_3), affected area of welding joint(ω_4) (Fig. (1-4));

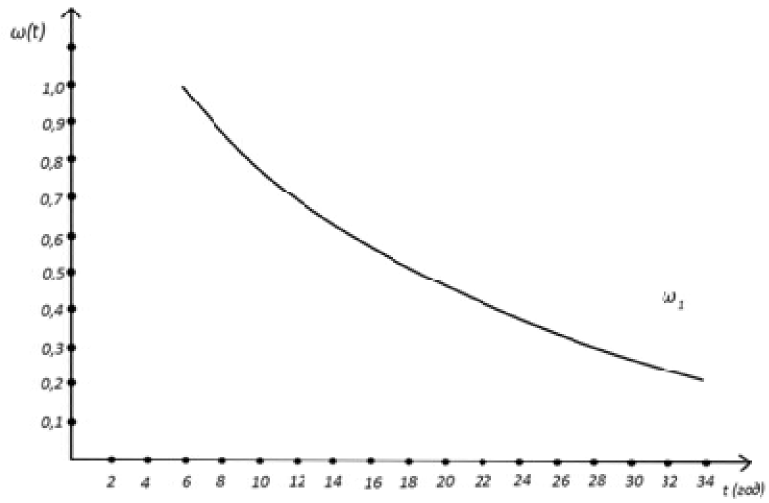

Fig.1. Dependence of quality parameters on time –base metal of pipes (ω_1)

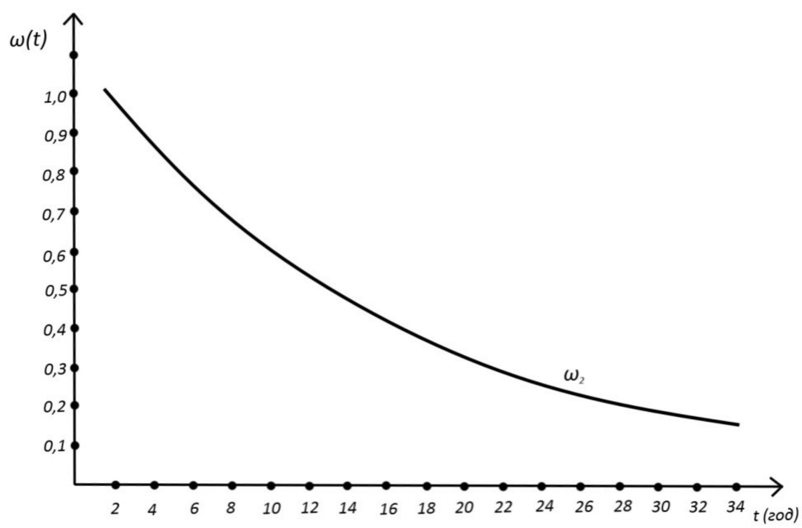

Fig.2. Dependence of quality parameters on time - shop weld (ω_2)

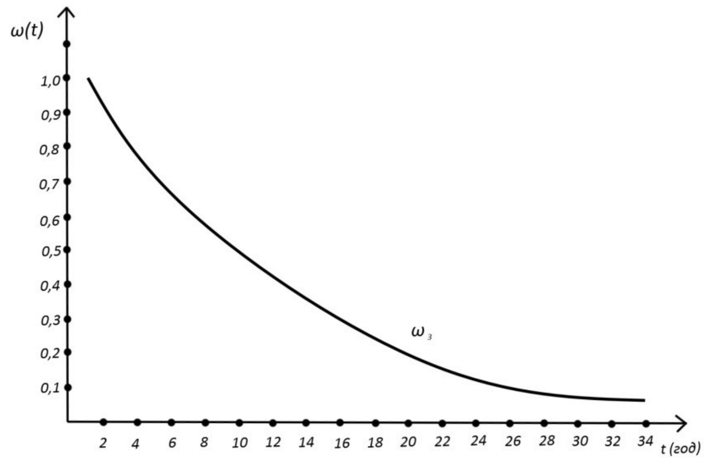

Fig.3. Dependence of quality parameters on time - welding joint (ω_3)

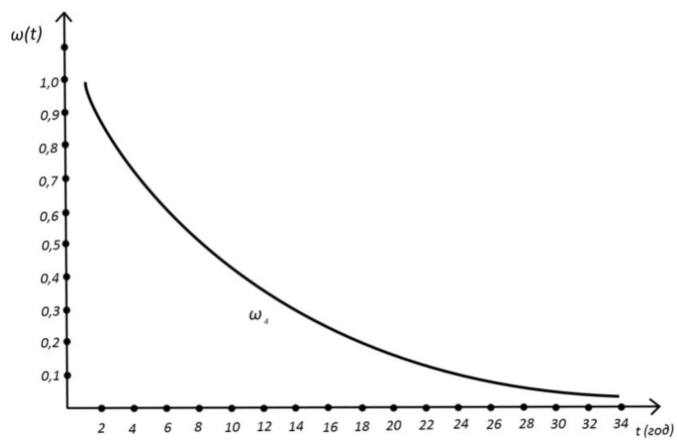

Fig.4. Dependence of quality parameters on time - affected area of welding joint (ω_4)

- as a result of the design errors(ω_5), calculation errors(ω_6), violation of design standards(ω_7) and rules of operation (ω_8) (Fig. (5-8));

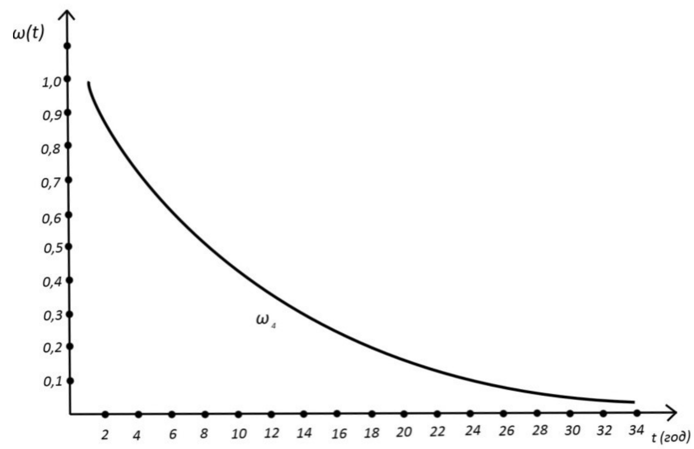

Fig.5. Dependence of quality parameters on time - design errors (ω_5)

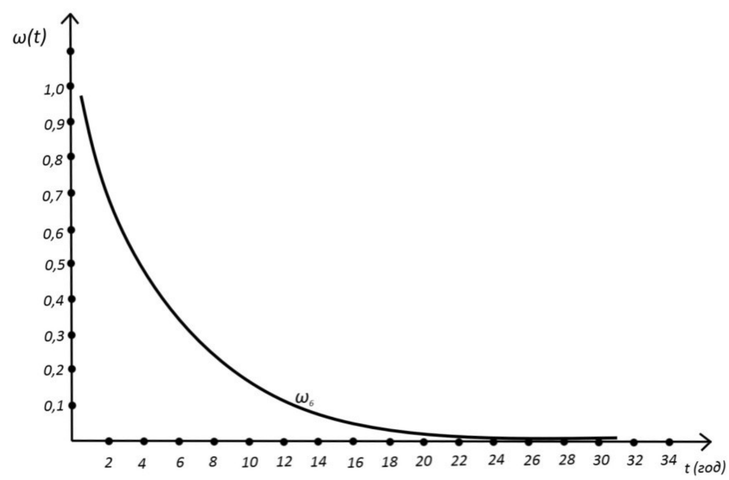

Fig.6. Dependence of quality parameters on time - calculation errors (ω_6)

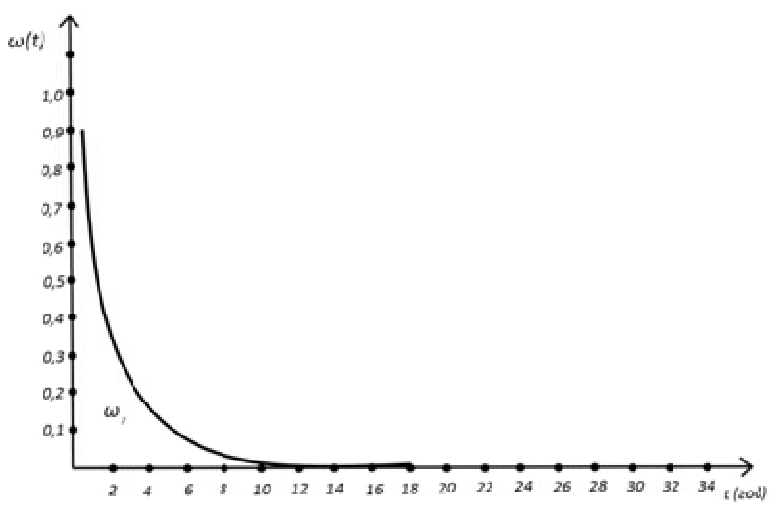

Fig.7. Dependence of quality parameters on time - violation of design standards (ω_7)

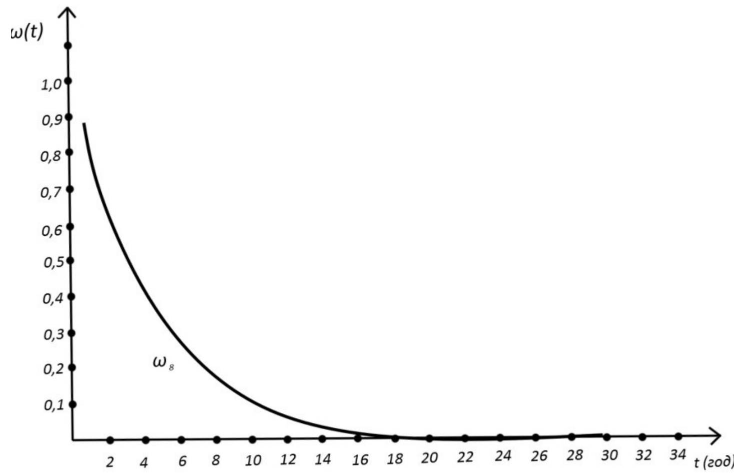

Fig.8. Dependence of quality parameters on time - violation of operating rules (ω_8)

- by the nature of demonstration (gradual, abrupt);
- bythe consequences of manifestation (connected with great losses of product, system downtime and material costs);
- by the method of troubleshooting (simple and complex).

Figure 9 presents all the quality parameters under study. It can be seen, that the violation of design standards the most significantly affects the studied object. The base metal of pipes has the least influence on the quality parameters of the structure [9, 10, 11].

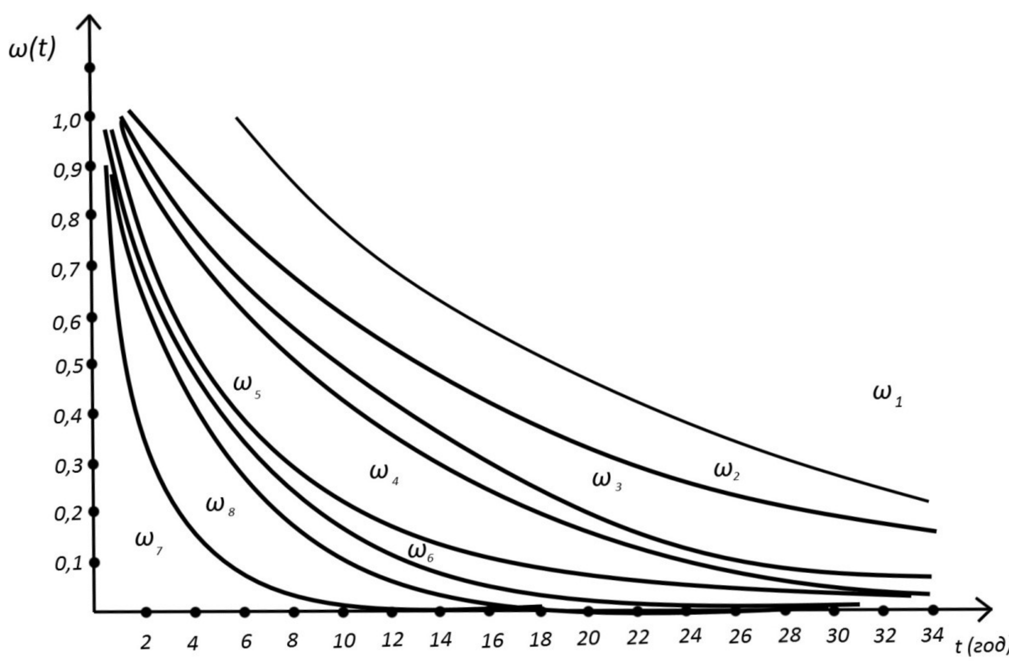

Fig.9. Dependence of quality parameters on time

4. DISCUSSION

Changes in the state of line section of the gas pipeline in any time interval (t) correspond to the increase in the increment parameter (ωi),it expresses the level of damages accumulation.This accumulation of damages can occur in any time interval. The actual change in the quality of line section of the gas pipeline can be expressed as follows [2, 9, 10]:

$$\Delta K = K_{(t+\Delta t)} - K_{(t)}, \quad (7)$$

where K - is the parameter of damages.

Taking into account the intensity of accumulation (development) of damages of the gas pipeline during operation, the parameter of damage is calculated as follows:

$$\Delta K_{(t)} = \mu \cdot K, \quad (8)$$

where μ - is a coefficient, depending on the intensity of damages.

During the period of operation, taking into account all parameters, affecting the quality of line section of the pipeline, it is possible to express:

$$\Delta K_{1(t)} = \mu_1 \omega_1$$

$$\Delta K_{2(t)} = \mu_2 \omega_2$$

$$\Delta K_{3(t)} = \mu_3 \omega_3$$

$$\Delta K_{i(t)} = \mu_i \omega_i$$

$$K = \Sigma \omega_i$$

The service life of line section of the gas pipeline depends on the combination of quality parameters. The control parameters are presented in Table 1.

Table 1. Quality control of the line section operation of the gas pipeline

Parameters	ω_1	ω_2	ω_3	ω_4	ω_5	ω_6	ω_7	ω_8
λ(1/year)	$0.9\cdot10^{-8}$	$1.2\cdot10^{-8}$	$0.8\cdot10^{-7}$	$0.6\cdot10^{-6}$	$1.7\cdot10^{-6}$	$3.1\cdot10^{-4}$	$1.1\cdot10^{-3}$	$1.5\cdot10^{-3}$
μ	0.01	0.02	0.1	0.2	0.3	0.38	0.35	0.4
t_c(year)	34	33	16	15	6	5.5	3	7

5. CONCLUSION

At present, there are many studies, devoted to the operational reliability of gas pipelines. All of them differ in their approaches and in relation to the term of reliability [10, 11].

The calculation, carried out as a result of investigations, is based on the statistical data on operation and failures of the line section of the gas pipeline. The developed model allows to calculatethe indicators of reliability and probability of failure-free operation of the gas pipeline. The proposed quality control method is based on operational data, including information about failures, design parameters and operating conditions of the gas pipeline.

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