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INVESTIGATION OF EFFECTIVE PLACEMENT OF CONNECTING FITTINGS TO PREVENT GAS LOSSES DURING OPERATION OF PARALLEL NETWORKS

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Abstract- One of the important tasks in gas supply systems is the independence of the operating mode of consumer enterprises from the operating mode of the gas distribution pipeline providing gas fuel, in other words, ensuring uninterrupted supply of these enterprises with gas. That is, it is important, not to make the work of consumer enterprises dependent on the operating mode of the distribution pipeline supplying them with gas fuel, and to organize an uninterrupted gas supply to these consumers. For this purpose, it is important to develop new technological bases for the operation of the network and to develop a theoretically based computational scheme to prevent gas losses due to modern equipment installed in gas transport networks. One of the solutions to the problem of improving the reliability of gas pipelines is the use of effective scientifically based technologies. In the article, the efficient placement of connecting fittings to prevent gas losses in the operation of parallel gas pipelines was investigated, and proposals were made for theoretical and technical bases of the operation of parallel gas pipelines.

Keywords: Parallel Gas Pipelines, Operation of Gas Pipelines, Pipeline Interconnector, Loopings, Multi-Line Gas Pipeline Network, Uninterrupted Gas Supply, Accident Mode, Optimal Fittings' Spacing.

1. INTRODUCTION

In stationary modes, the dynamic state of gas networks remains stable along the entire length of the gas pipeline, regardless of time, and therefore does not cause problems in the operation of control stations. However, in non-stationary modes, that is, in emergency modes, due to changes in the dynamic state of gas pipelines, targeted control of the operating mode is of great importance. At this time, to increase the reliability of networks and prevent gas losses, it is necessary to install additional fittings and equipment. In other words, a new computational scheme must be developed for the uninterrupted supply of gas to consumers and the amount of gas lost into the environment.

1.1. Determination of Distance between Connectors in Order to Avoid Losses in Operation of Gas Pipelines

It should be noted that the amount of gas lost to the environment when an accident occurs in pipelines also depends on the distance between the connecting fittings. Thus, when accidents occur on pipelines, the damaged part is separated from the main part of the gas pipeline by the connectors. The main purpose of the separation is to create conditions for repairing the damaged part of the pipe. Since maintenance work on the network in operation is a dangerous one, it should be performed according to the appropriate rules and instructions. Failure to comply with these requirements can lead to accidents such as burns, explosions, and poisoning. Therefore, the executor is given a separate task for each repair. In these tasks, the composition of the brigade and the rules of safe working conditions, the permissible pressure for carrying out repairs should be specified.

2. PROBLEM STATEMENT

The normal pressure that can be left on the tape for repair is considered to be between 200 and 1200 Pa. Reducing the pressure to "0" at low pressures can create a risk of explosion in the gas pipeline due to the air mixture there. At low pressures, dropping the pressure to "0" can create a risk of explosion in the gas pipeline due to the air mixture in the pipeline. If the pressure is higher than the norm, it will practically not allow welding. Therefore, repairs to gas pipelines take a long time. During this period, the operating regime of gas supply to consumers is disrupted, and large amounts of gas are also released into the environment as a raw material. The amount of gas released into the environment is the sum of the losses resulting from two processes:

1) Gas lost into the environment during the period up to the closure of the automatic taps.
2) In terms of maintenance safety, the emptying of the pipeline between closed taps ensures that the gas is mixed with the environment (Figure 1).

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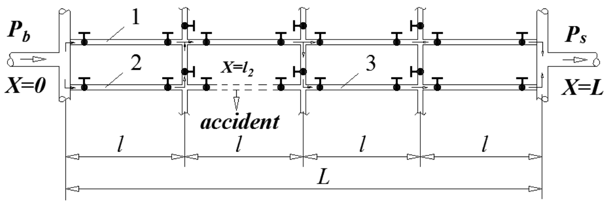

Figure 1. Scheme of connecting the sections in the accident mode of parallel gas pipelines

3. PROBLEM SOLUTION

The amount of gas lost in the initial operation is not dependent on the distance resulting from the placement of the automatic taps. In the second operation, the amount of gas lost is directly dependent on the distance between the automatic taps. So, the longer the distance between the taps, the greater the amount of gas lost into the environment. On the other hand, as can be seen from the diagram Figure 1, the smaller the distance between the automatic taps' tubes, the higher the cost of the pipeline. That is why we need to determine the distance between the automatic tap's tubes economically. So, the existing gas pipeline needs to have a number of automatic taps that do not exceed the cost of the pipeline due to the damage caused by the gas lost to the environment. That is to say.

$$S_{p.c.} \le S_l \tag{1}$$

where, $S_{p.c.}$ is the cost incurred in the pipeline as a result of the installation of automatic taps on the pipeline and is determined depending on the operation mode and type of tap. S_l is damage caused by the release of gas into the environment in emergency mode is defined below:

$$S_l = (Q_1 + Q_2) \times C_{gas} \text{ €} \tag{2}$$

where, Q_1 is the amount of gas lost in the period from the moment of the accident to the time when the automatic taps are closed, m^3. Q_2 is the amount of gas lost as a result of the emptying of the band for repair of the damaged part after the automatic taps are started, m^3, and C_{gas} is the cost of 1 m^3 of gas, €/m^3.

First of all, let's determine the amount of gas that has been lost in the period until the automatic tubes are shut down. For this purpose, in order for the gas pipeline shown in Figure 1 to be operational, the dynamic state of all processes must be determined in accordance with the operating principle when an accident occurs. In other words, by determining the mathematical solution of the occurring physical processes, we need to find the time-dependent distribution of the gas flow parameters along the pipeline. When parallel gas transmission systems operate in emergency mode, the system of specially derived nonlinear equations that mathematically represent the physical processes of the non-stable flow of a gas flow is as follows [1].

$$\begin{cases} -\dfrac{\partial P}{\partial X} = \lambda \dfrac{\rho V^2}{2d} \\ -\dfrac{1}{c^2}\dfrac{\partial P}{\partial t} = \dfrac{\partial G}{\partial X} \end{cases} \tag{1}$$

where, c is the speed of sound transmission of the gas for isothermal processing, m/sec, P is the pressure in the sections of the gas pipeline, Pa, x is coordinates along the axis of the gas pipeline, km, t is time coordinates, sec, λ is hydraulic resistance coefficient, ρ is average gas density, kg/m^3, V is average gas flow rate, m/sec, d is gas pipeline diameter, m, and G is gas flow mass consumption, $\dfrac{\text{Pa}\times\text{sec}}{\text{m}}$.

It is clear that Equation (1) cannot be solved nonlinearly. Because these kinds of equations are not integrable at the moment. Approximate methods are used in engineering calculations. In other words, the equations are corrected. They use the following rationalization techniques to solve the equations: During the calculations, I.A. Charnov's method of rectangulation was shown to be more appropriate when the belts are out of order. The expression that characterizes this righteousness is as follows [4]:

$$2a = \lambda \frac{V}{2d} \tag{2}$$

where, 2a is Charnov's rationalization coefficient, then the Equation (1) becomes as the Equation (3).

$$\begin{cases} \dfrac{\partial P}{\partial X} = 2aG \\ -\dfrac{1}{c^2}\dfrac{\partial P}{\partial t} = \dfrac{\partial G}{\partial X} \end{cases} \tag{3}$$

where, $G=\rho v$; $P=\rho c^2$.

If we derive Equation (3) system from the 1st expression and the 2nd expression according to x, if we set $\dfrac{\partial G}{\partial X}$, then;

$$\begin{cases} -\dfrac{\partial^2 P}{\partial X^2} = 2a\dfrac{\partial G}{\partial X} \\ \dfrac{\partial G}{\partial X} = -\dfrac{1}{c^2}\dfrac{\partial P}{\partial t} \end{cases} \tag{4}$$

If we replace the $\dfrac{\partial G}{\partial X}$ Equation in the (4) Equation (1) of the equation system, we get the heat transfer equation for the mathematical solution of the problem.

$$\frac{\partial^2 P}{\partial X^2} = \frac{2a}{c^2}\frac{\partial P}{\partial t} \tag{5}$$

Solution of Equation (5) to be the only solution and for the given process to be properly determined. The distribution of the requested function (pressure) at t=0 is given when the starting conditions and inactivity forces are not taken into account. The boundary conditions will ensure a pre-determined regular change in pressure and flow at the end points of the pipeline during the time of the process considered [2]. Providing the correct boundary conditions completes the mathematical model of the process and enables a thorough and accurate study of occurring physical events.

t=0; $P_i(x,0) = P_b - 2aG_0x$: i=1, 2

In the process of treating the three points, we accept the boundary conditions (the flow is measured at the starting and ending points) as follows [4].

at x=0 $\begin{cases} P_1(x,t)=P_2(x,t) \\ \dfrac{\partial P_1(x,t)}{\partial X}+\dfrac{\partial P_2(x,t)}{\partial X}=-2aG_0(t) \end{cases}$

at x= L $\begin{cases} P_1(x,t)=P_3(x,t) \\ \dfrac{\partial P_1(x,t)}{\partial X}+\dfrac{\partial P_3(x,t)}{\partial X}=-2aG_S(t) \end{cases}$

at x= l_2 $\begin{cases} P_2(x,t)=P_3(x,t) \\ \dfrac{\partial P_2(x,t)}{\partial X}-\dfrac{\partial P_3(x,t)}{\partial X}=-2aG_{ut}(t) \end{cases}$

where, $G_0(t)$, $G_s(t)$ and $G_{ut}(t)$ are the value of the mass flow measured at different times at the leak point for the start [9], end, and emergency modes of the gas pipeline, $\frac{\text{Pa}\times\text{sec}}{\text{m}}$.

When the mode of gas pipelines is broken, the Laplace conversion method is preferred in practice. Laplace transformation means. $P(x,S)=\int_0^{\infty y} P(x,t)e^{-st}dt$ integral. Where, S=a+i_b is called a complex number, $i=\sqrt{-1}$ a virtual number [3]. Thus, if we apply the Laplace conversion method to heat transfer Equation (5), we get a two-shape equation.

$$\frac{d^2P(x,S)}{dx^2}=\frac{2a}{c^2}\left[SP(x,S)-P(x,0)\right] \quad (6)$$

It is clear that the general solutions of the second-level differential Equation (6) will be as follows:

$$P_i(x,S)=\frac{P_i(x,o)}{S}+A_1Sh\sqrt{\frac{2as}{c^2}}x+B_1Ch\sqrt{\frac{2as}{c^2}}x \quad (7)$$

Applying the Laplace transformation to the starting and boundary conditions, we find the Ai and Bi coefficients in Equation (7). Taking into account the values of the coefficients in Equation (7), we get the transformed equation of the process in question, in other words the dynamic state of the gas pipeline. These equations will represent the reverse distribution of pressure throughout the band for the sections considered.

$$P_1(x,S)=\frac{P_b-2aG_1x}{S}+Z_2-\frac{2aG_{ut}(S)}{2\sqrt{\mu s}}\frac{ch\sqrt{\mu s(L-\ell_2-x)}}{sh\sqrt{\mu s}2L} \quad (8)$$

$$P_2(x,S)=\frac{P_b-2aG_2x}{S}+Z_2-\frac{2aG_{ut}(S)}{2\sqrt{\mu s}}\times\frac{ch\sqrt{\mu s(L-\ell_2+x)}}{sh\sqrt{\mu s}L} \quad (9)$$

$$P_3(x,S)=\frac{P_b-2aG_2x}{S}+Z_2-\frac{2aG_{ut}(S)}{2\sqrt{\mu s}}\frac{ch\sqrt{\mu s(L+\ell_2-x)}}{sh\sqrt{\mu s}L} \quad (10)$$

where, $\mu=\frac{2a}{c^2}$.

$$Z_2=\frac{2aG_0}{2S\sqrt{\mu s}}\frac{sh\sqrt{\mu s}\left(x-\frac{L}{2}\right)}{ch\sqrt{\mu s}\frac{L}{2}}+\frac{2aG_0(S)}{2\sqrt{\mu s}}\frac{ch\sqrt{\mu s}(L-x)}{sh\sqrt{\mu s}L}-\frac{2aG_k(S)}{2\sqrt{\mu s}}\frac{ch\sqrt{\mu s}x}{sh\sqrt{\mu s}L}$$

Since it is more appropriate to determine the mathematical expression of the physical process of the non-stable flow of a gas flow based on the solution of the problem in an undamaged configuration, we will use the inverse Laplace conversion rule of each limit (8÷10) to find the original solution of the equations. So, according to the starting and boundary conditions, we get the following mathematical expression of the distribution of pressure along the belt axis as a function of time.

$$P_1(x,t)=Z_2-\frac{c^2}{L}\sum_{n=1}^{\infty}\cos\frac{\pi n(\ell_2+x)}{L}\int_0^t G_{ut}(\tau)\times e^{-\alpha_2(t-\tau)}d\tau \quad (11)$$

$$P_2(x,t)=Z_2-\frac{c^2}{L}\sum_{n=1}^{\infty}\cos\frac{\pi n(x-\ell_2)}{L}\int_0^t G_{ut}(\tau)\times e^{-\alpha_2(t-\tau)}d\tau \quad (12)$$

$$P_3(x,t)=P_2(x,t),\ \ell_2\le x\le L \quad (13)$$

where, $\alpha_1=\frac{\pi^2(2n-1)^2c^2}{8aL^2}$, $\alpha_2=\frac{\pi^2n^2c^2}{8aL^2}$.

$$Z_2=P_b-2aG_o\frac{L}{4}+4aG_oL\sum_{n=1}^{\infty}\frac{e^{-\alpha_1 t}}{\left[\pi(2n-1)\right]^2}\times\cos\frac{\pi(2n-1)x}{L}+\frac{c^2}{L}\sum_{n=1}^{\infty}\cos\frac{\pi nx}{L}\int_0^t\left[G_0(\tau)-(-1)^nG_k(\tau)\right]\times e^{-\alpha_2(t-\tau)}d\tau+\frac{c^2}{2L}\int_0^t\left[G_0(\tau)-G_k(\tau)-G_{ut}(\tau)\right]d\tau$$

For the emergency mode of a parallel gas pipeline operating in a smooth hydraulic mode, we accept Equations (11)-(13) and depending on the different gas leakage points along the line of damaged and undamaged structures: Data for determining the regularity of gas pressure changes.

P_b = 55×10^4 MPa: P_s = 40×10^4 MPa: G_0= 30 Pa×sec/m = 3 kg×sec/m^3; $2a=1/\sec$; c = 383.3m/sec L = 10^5 m; l_2= 0.25×10^4 m; l_2= 0.5×10^4 m; l_2= 0.75×10^4 m: d= 0.7 m

First, we take the l_2= 0.25×10^4 m; l_2= 0.5×10^4 m; l_2=0.75×10^4 m leakage points in the gas pipeline and write them down in Table 1, calculating the pressure values in the gas pipeline at t = 300 seconds every 5 km for each of its various locations. Let's plot the distribution of the instantaneous pressure t = 300 sec along pipeline line, depending on the various leak sites in the pipeline using Tables 1 and 2 (Figure 2). The arrangements on parallel gas pipelines operating in single hydraulic mode have a common starting and ending point. Therefore, when one of the systems is damaged, total amount of gas is directed to the damaged part of gas pipeline.

Table 1. Distribution of instantaneous pressure t = 300 sec along the pipeline line, l_2= 0.25×10^4 m

x (km)	l_2= 0.25× 10^4 m		
	P_1 (x, t) 10^4 Pa	P_2 (x, t) 10^4 Pa	P_3 (x, t) 10^4 Pa
0	49.1	49.1	-
5	48.83	47.49	-
10	48.7	45.78	-
15	48.5	43.92	-
20	48.22	41.92	-
25	47.88	39.75	39.75
30	47.48	-	40.42
35	47.03	-	40.92
40	46.54	-	41.28
45	46	-	41.49
50	45.42	-	41.6
55	44.81	-	41.6
60	44.17	-	41.52
65	43.49	-	41.36
70	42.78	-	41.13
75	42.05	-	40.84
80	41.28	-	40.51
85	40.49	-	40.13
90	39.67	-	39.72
95	39.31	-	39.29
100	38.81	-	38.81

Table 2. Distribution of instantaneous pressure t = 300 sec along the pipeline line, l_2= 0.75× 10^4 m

x (km)	l_2= 0.75× 10^4 m		
	P_1 (x, t) 10^4 Pa	P_2 (x, t) 10^4 Pa	P_3 (x, t) 10^4 Pa
0	53.81	53.81	-
5	52.31	52.78	-
10	51.67	51.72	-
15	50.99	50.63	-
20	50.28	49.51	-
25	49.55	48.34	-
30	48.78	47.13	-
35	47.99	45.86	-
40	47.17	44.52	-
45	46.31	43.1	-
50	45.42	41.6	-
55	44.5	39.99	-
60	43.54	38.28	-
65	42.53	36.42	-
70	41.48	34.42	-
75	40.38	32.25	32.25
80	39.22	-	32.92
85	38	-	33.42
90	36.7	-	33.78
95	35.33	-	33.99
100	34.1	-	34.1

Figure 2 shows the location of leakage points does not alter the quality of the image. Using Equation (11), first define expression P_1 (0, t), characterizing the pressure change at the starting point of the pipeline (x=0), and expression P_2 (L, t), characterizing the pressure change at the end point of the pipeline, point (x=L), using Equations (12). After we accept simplifications $G_0(\tau) = G_k(\tau), G_{ut}(\tau) = \text{const}$ for the case n=2 using Himin expressions, we define the difference of functions; $\left[P_1(0,t) = P_b(0,t)\right] - \left[P_2(L,t) = P_s(L,t)\right]$

as follows.

$$P_1(0,t) - P_2(L,t) = P_b - P_s - 2aG_{ut}\frac{L}{2} + 2aG_{ut}l_2$$

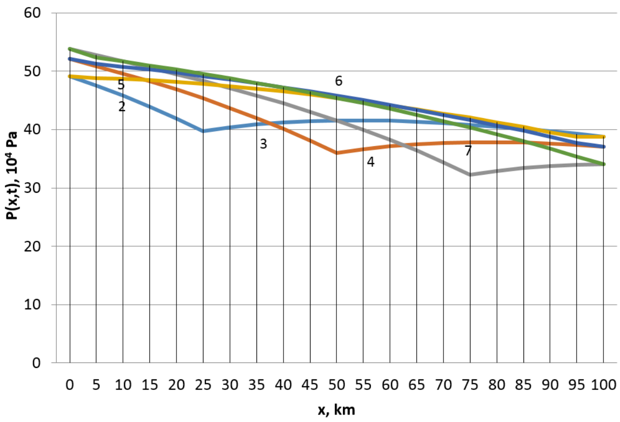

Figure 2. Distribution of pressure along a faulty parallel gas pipeline line depending on the different locations of the leak,
1: fixed mode pressure change;
2-3-4: 1st (harmless) change of pressure in adjustment;
5-6-7: 2nd order pressure change (damaged);
5-2: l_2= 0.25×10^4 m; 6-3: l_2= 0.5×10^4 m; 7-4: l_2= 0.75×10^4 m

where, taking into account that $P_s = P_b - 2aG_0L$ we get

$$P_b(0,t) - P_s(L,t) = 2aG_0L + 2aG_{ut}\left[l_2 - \frac{L}{2}\right] \quad (14)$$

We use Equation (14) to determine the mass consumption (G_{ut}) of the gas lost into the environment in emergency mode.

$$G_{ut} = \frac{P_b(0,t) - P_s(L,t) - 2aG_0L}{2a\left[l_2 - \frac{L}{2}\right]} \quad (15)$$

As we know, the duration of the location of the leakage points and the working time of the automatic taps attached to the pipeline are taken equally [3, 7]. That is, the location of the leak point is determined, and the position of the pre-assembled connectors is known in the pipe network. If the time to locate the leak point is t = t_1, and the dependency between mass consumption and volume consumption is

$$Q = G_{ut}\frac{Fg}{\rho}$$

Then the Equation (15) will be expressed as follows:

$$Q_1 = \frac{Fgt_1}{2a\rho} \times \frac{P_s(0,t) - P_s(L,t) - 2aG_0L}{\left[l_2 - \frac{L}{2}\right]} \quad (16)$$

Obviously, to prevent the gas from leaking into the environment, they turn off the automatic taps brackets on the right and left of the damaged part at t=t_1. We obtained Equation (16) by taking the integral of Equation (15) to determine the total amount of gas lost from the leak point into the environment $\left(0 \le t \le t_1\right)$,

$$\int_0^{t_1} G_{ut}dt = G_{ut}t_1$$

where, F is the cross-sectional area of the gas pipeline, m^2, g is acceleration of gravity, m/sec^2, ρ is the average density of gas in the cross-sectional area, kg/m^3, $2a$ is the value of the smoothing factor, l/sec, P_b $(0,t)$ is the pressure at the starting point of the gas pipeline at time $t=t_1$ during the accident mode, kg/m^2, $P_s\ (L,t)$ is the pressure at the end point of the gas pipeline at time $t=t_1$ during the accident mode, kg^2/m^2, G_0 is mass flow rate of gas in stationary mode, kg×sec/m^3, L is length of the gas pipeline, m, and l_2 is distance from the starting point of the gas pipeline to the leakage point, m.

Now, let's determine the amount of gas lost after the emergency shutdown of the automatic taps. The amount of gas lost during this period will be determined by the following expression, depending on the distance between the taps:

$$Q_2 = F \times l \times \frac{P_m}{P_0} \times \frac{T_m}{T_0}\text{, m}^3 \quad (17)$$

where, P_m is represents the average pressure in the gas pipeline and is determined as follows:

$$P_m = \frac{2}{3}\left(P_b + \frac{P_s^2}{P_b + P_s}\right)\text{, kg/m}^2$$

where, P_0 is represents the value of atmospheric pressure, with $P_0 = 10^4$ kg/m^2, T_m is top is the average temperature of gas in the pipeline, assumed to be within the range of 298 to 323 K, and T_0 is the absolute temperature of the gas at 0 °C, with a value of $T_0 = 293\text{K}$.

Considering Equations (16) and (17) in the inequality of Equation (1), then,

$$S_{p.c.} \le \left[\frac{Fgt_1}{2a\rho}\frac{P_b(0,t) - P_s(L,t) - 2aG_0 \times L}{\left[l_2 - \frac{L}{2}\right]} + F \times l \frac{P_m}{P_0}\frac{T_m}{T_0}\right] \times C_{gas} \quad (18)$$

By replacing the '≤' sign with the '=' sign in Equation (18), we can economically determine the distance between automatic taps. From here,

$$l = \frac{P_o}{F \times P_{or}}\frac{T_o}{T_{or}} \times \left[\frac{S_{kx}}{C_{qaz}} - \frac{Fgt_1}{2a\rho}\frac{P_b(0,t) - P_s\ (L,t) - 2aG_0L}{\left[l_2 - \frac{L}{2}\right]}\right] \quad (19)$$

By substituting the values of the constants into Equation (19) and making a few straight forward replacements, we obtain the distance between automatic taps as follows: $\rho = 0.73$ kg/m^3, $2a = 0.1$ l/sec , $T_m = 323\text{K}$ are assumed.

$$l = \left[\frac{10767}{P_{or}} \times \frac{C_{kx}}{C_{qaz} \times d^2} - 113.6 \times \frac{t_1}{P_{or}}\frac{P_b(0,t) - P_s(L,t) - 0.1 \times G_0 \times L}{l_2 - \frac{L}{2}}\right] \quad (20)$$

To determine the length of the effective distance between the cranes to be installed on the gas pipeline according to the Equation (20), we take the above initial data of the gas pipeline:

P_b = 55×10^4 MPa: P_s = 40×10^4 MPa: G_0= 30 Pa×sec/m= 3 kg×sec/m^3; $2a = \frac{1}{\text{sec}}$; $c = 383.3\frac{m}{\text{sec}}$; L = 10^5 m; d= 0.7 m;

Using Table 1, we take the values $P_1(0, t_1)$ and $P_2(L, t_1)$ of the pressures at the beginning and end of the belt for option l_2 =0.75×10^4 m of the leakage points for t_1=300 seconds.

$P_1(0, t_1) = P_b(0, t)$ = 53.81×10^4 Pa= 5.381×10^4 kg/m^2;
$P_2(L, t_1) = P_s(L, t)$ = 34.1×10^4 Pa =3.41×10^4 kg/m^2

The cost of installing an automatic crane with an electric drive with a diameter of d=0.7 m (steel DN 700 En, PN 25 C) $S_{p.c.}$= 150000 € can be accepted. Considering the current cost of 1 m^3 of gas as C_{gas}=300 €/m^3, we can determine the economically optimal distance between the s using the principle outlined in Equation (20). First, we determine the value of the average pressure in the gas pipeline.

If $P_{or} = 4.79 \times 10^4$ kg/m^2, $l = 7344$ m.

Therefore, in order to avoid losses in the operation of gas pipelines, it is technologically and economically efficient that the distance between the connectors should be l=7344 m according to the initial data above. The analysis of the diagram in Figure 1 suggests that after the automatic tubes have been shut down, the connectors placed on the right and left of the leakage point of the band should be operated simultaneously.

According to the rules of technical design of main gas pipelines, emergency automatic valves must ensure that the valves are turned off if the pressure in the gas pipeline drops to 10-15% of the operating pressure within 1-3 minutes. Linear connection fittings must be remotely controlled in accordance with the standards of the technological project. SNiP 2.05.06-85* in accordance with clause 12.10, the distance between the linear connecting fittings installed on the pipeline should not exceed 10 km. On the other hand, when laying main gas pipelines in parallel, connectors must be provided: - for gas pipelines with the same pressure - with connecting fittings. The connectors are located on linear cranes (before and after cranes) at a distance of at least 40 km and not more than 60 km from each other.

Based on our theoretical research, it was found that the distance between the connectors can vary depending on the parameters of the parallel gas pipeline, the type of consumers and the cost of the equipment to be installed. Therefore, the proposed new reporting scheme will have a significant impact on the effective placement of links. From the above-mentioned considerations, it can be concluded that the picture of changes in the dynamic state of the pipeline, as well as the level of gas supply to consumers, directly depends on the distance between automatic cranes. Therefore, during the operation of pipelines, determining the distance between automatic cranes installed on them is one of the basic principles of designing gas pipelines.

4. CONCLUSIONS

Mathematical modeling based on the numerical solution of a complete system of equations describing the unsteady gas flow in a gas pipeline is used as the initial basis. Since the object of the study is not only the network itself, but also the connecting fittings and connectors, a complete system of gas dynamic equations was taken into account to determine its dynamic state in all processes, in accordance with the principle of operation in the event of an emergency event. During the analysis, the distribution of gas pressures along the length of the gas pipeline at various points of the leakage point was studied. Violation of the tightness of one of the lines directly leads to a change in the operating mode of the other. It is established that the qualitative picture of the dynamic state of the damaged line is similar to that of an intact line. However, regardless of the operating conditions of the gas pipeline, the pressure drop rate at the leak point of the damaged pipeline is about 2-3 times higher than the pressure of the intact gas pipeline at this point.

The application of the proposed new design scheme for uninterrupted gas supply to consumers for various purposes, powered by a pipeline network during the operation of parallel gas pipelines, not only avoids losses during the operation of gas pipelines, but at the same time is acceptable for determining the optimal parameters of connecting fittings. It can be concluded from the above that the dynamic state of the pipeline and the level of gas supply to consumers depend directly on the distance between the automatic taps. Therefore, the determination of the distance between the automatic cranes to be installed in the pipeline operation process is one of the basic principles of the design of gas pipelines.

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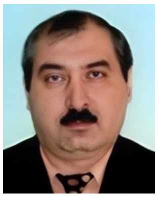

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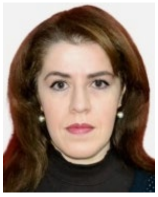

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