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Satbayev University

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ИЗВЕСТИЯ

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E.Kh. Iskandarov[1], Sh.A. Baghirov[2]*

[1]Azerbaijan State Oil and Industry University, Baku, Azerbaijan;
[2]NOV Azerbaijan LLC, Baku, Azerbaijan.
E-mail: Shahriyar.baghirov@gmail.com

ANALYTICAL AND WAVE-DEPRESSION METHODS OF ELIMINATION OF THE ONSET OF HYDRATION IN SUBSEA GAS PIPELINES

Abstract. The article is devoted to the operative determination of hydration in the process of transportation of natural by subsea gas pipeline and the analysis of methods for the elimination of hydrate already formed.

As a result of the analysis, it was noted that one of the most difficult problems in the transportation of natural gas, especially by sea, is formation of hydrates. The need has been highlighted to carry out a complex and time-consuming process, such as the suspension and release of hydrate from subsea gas pipelines as a result of hydrate formation and complete riveting.

It was noted that the process that takes more time and causes more losses in the transport system is the melting of the resulting hydrate. For such cases, the use of special methods of influence was considered expedient.

It is noted that the second scenario of hydration in gas pipelines and partial or complete blockage of the pipeline occurs more often at the end of the winter season - the beginning of the spring season. This is due to the fact that large amounts of free water and condensate accumulate inside the pipeline as a result of the phase transformations that take place during the past winter season. For this reason, the cross-section of the pipeline decreases in the fluid-collecting sections of the pipeline, which results in an increase in the gas flow rate in that section, a decrease in the gas temperature due to post-section expansion, and hydrate formation.

Unlike onshore gas pipelines, the number of technological parameters is very limited to accurately assess the moment of onset of hydrate formation in subsea offshore gas pipelines. An analytical method for determining the onset of hydration and the wave-depression method of elimination of the already formed hydrate in a subsea gas pipeline are presented under limited parameters given. Reports for the real gas pipeline have demonstrated the effectiveness and informativeness of the methods. The proposed methods are characterized by simplicity, the possibility of operational implementation and ease of use by staff.

Key words: natural gas, gas hydrate, analytical method, wave-depression method, subsea pipeline, indication of hydrate formation, blockage, methanol.

Э.Х. Искандаров[1], Ш.А. Багиров[2]*

[1]Әзербайжан мемлекеттік мұнай және өнеркәсіп университеті, Баку, Әзірбайжан;
[2]NOV Azerbaijan ЖШҚ, Баку, Әзірбайжан.
E-mail: Shahriyar.baghirov@gmail.com

ТЕҢІЗГЕ ГАЗ ҚҰБЫРЛАРЫНДАҒЫ ГИДРАТТЫҢ ТҮЗІЛУІНІҢ АЛДЫН АЛУ ҮШІН АНАЛИТИКАЛЫҚ ЖӘНЕ ТОЛҚЫНДЫ-ДЕПРЕССИЯЛЫҚ ӘДІСТЕР

Аннотация. Мақала гидрат түзілудің басталуын жылдам анықтаудың аналитикалық әдісін және табиғи газды су асты газ құбыры арқылы тасымалдау кезінде пайда болған гидратты жою әдісін әзірлеуге арналған.

Талдау нәтижесінде табиғи газды, әсіресе теңіз арқылы тасымалдаудағы күрделі мәселелердің бірі гидраттардың түзілуі екені айтылды. Су асты газ құбырларының гидраттарын толық бітеумен бөлу және шығару сияқты күрделі және көп уақытты қажет ететін процесті жүргізу қажеттілігі анықталды. Түзілген гидратты балқыту процесі ұзаққа созылатыны және көлік жүйесінде үлкен шығындарға әкелетіні атап айтылды. Мұндай жағдайлар үшін әсер етудің арнайы әдістерін қолдану орынды деп саналады. Газ құбырларында гидраттардың пайда болуының және олардың ішінара немесе толық бітелуінің екінші сценарийі қыс мезгілінің аяғында – көктемнің басында жиі орын алатыны көрсетілді. Себебі, өткен қыс мезгілінде орын алған фазалық өзгерістер нәтижесінде құбыр ішінде бос су мен конденсаттың көп мөлшері жиналған. Осы себепті газ құбырының төменгі учаскелерінде құбырдың көлденең қимасы азаяды, бұл осы учаскеде газ жылдамдығының жоғарылауына, одан әрі кеңею және гидраттардың пайда болуына байланысты газ температурасының төмендеуіне әкеледі.

Құрлықтағы газ құбырларынан айырмашылығы, су асты газ құбырларында гидрат түзілудің басталуын дәл бағалау үшін технологиялық параметрлердің саны өте шектеулі. Гидратацияның басталуын анықтаудың аналитикалық әдісі және шектеулі параметрлері бар су асты газ құбырында қалыптасқан гидратты жоюдың толқынды-депрессиялық әдісі ұсынылған. Нақты газ құбыры туралы есептер әдістердің тиімділігі мен ақпараттылығын көрсетті. Ұсынылған әдістер қарапайымдылығымен, жедел орындау мүмкіндігімен және пайдаланудың қарапайымдылығымен сипатталады.

Түйін сөздер: табиғи газ, газгидрат, аналитикалық әдіс, толқын-депрессия әдісі, су асты құбыры, гидрат индикаторы, бітеу, метанол.

Э.Х. Искандаров[1], Ш.А. Багиров[2]*

[1]Азербайджанский государственный университет нефти и промышленности, Баку, Азербайджан;
[2]ООО NOV Азербайджан, Баку, Азербайджан.
E-mail: Shahriyar.baghirov@gmail.com

АНАЛИТИЧЕСКИЙ И ВОЛНО-ДЕПРЕССИОННЫЙ МЕТОДЫ ПРЕДОТВРАЩЕНИЯ ГИДРАТООБРАЗОВАНИЯ В МОРСКИХ ГАЗОПРОВОДАХ

Аннотация. Статья посвящена разработке аналитического метода оперативного определения начала гидратообразования и метода ликвидации уже образовавшегося гидрата при транспортировке природного газа по подводному газопроводу.

В результате анализа было отмечено, что одной из самых сложных проблем при транспортировке природного газа, особенно морским путем, является образование гидратов. Выявлена необходимость проведения такого сложного и трудоемкого процесса, как расщепление и вынос гидрата из подводных газопроводов при их полной закупорке.

Отмечено, что процесс таяния образовавшегося гидрата занимает много времени и вызывает большие потери в транспортной системе. Для таких случаев считается целесообразным применение специальных методов воздействия.

Отмечено, что второй сценарий гидратообразования в газопроводах и их частичная или полная закупорка чаще происходит в конце зимнего сезона – начале весеннего. Это связано с тем, что в результате фазовых превращений, происходивших в течение прошедшего зимнего сезона, внутри трубопровода скапливается большое количество свободной воды и конденсата. По этой причине на пониженных участках газопровода уменьшается поперечное сечение трубопровода, что приводит к увеличению скорости газа на этом участке, снижению температуры газа за счет дальнейшего расширения и образованию гидратов.

В отличие от наземных газопроводов, количество технологических параметров для точной оценки момента начала гидратообразования в подводных морских газопроводах весьма ограничено. Представлены аналитический метод определения начала гидратации и волно-депрессионный метод ликвидации уже образовавшегося гидрата в подводном газопроводе при ограниченных параметрах. Отчеты по реальному газопроводу продемонстрировали эффективность и информативность методов. Предлагаемые методы характеризуются простотой, возможностью оперативного выполнения и удобством использования персоналом.

Ключевые слова: природный газ, газовый гидрат, аналитический метод, волно-депрессионный метод, подводный трубопровод, индикатор гидратообразования, закупорка, метанол.

Introduction. Natural gas has a number of competitive advantages over other types of energy. One of the main advantages is low cost and environmental friendliness in use. As the world community seeks to reduce the amount of harmful emissions into the atmosphere, the use of natural gas as the main type of energy source is very relevant. Gas as a fuel is a universal and valuable energy source, so it has a direct impact on the growth of industrial and agricultural production, labor productivity and the reduction of specific consumption of liquid fuels (Istomin, 2004: 508). Due to the fact that natural gas production areas are located far from the places of consumption, there is a need to deliver natural gas from the places of production to the final points of consumption.

One of the most difficult problems in the transportation of natural gas, especially by subsea pipelines, is hydration.

Research materials and methods. Gas hydrates (hydrates or clathrates of natural gases) are crystalline compounds formed from water and gas under certain temperature and pressure conditions. Gas hydrates are non-stoichiometric compounds, ie. compounds with variable composition (Mirzejanzade, 2003: 54).

Gas hydrates (clathrates) are compounds of low molecular weight gases such as, methane, ethane, propane, butane, etc. with water.

Gas hydrates are divided into natural and technogenic types.

Technogen hydrates, which are the subject of research, can be formed in traditional natural gas production systems (in the near wellbore zone, inside tubing, etc.) and in the process of its transportation. The formation of gas hydrates in the technological processes of production and transportation of conventional natural gas is considered an undesirable phenomenon, which implies further improvement of methods for their prevention and elimination (Khairullin, 2005: 103).

It should be kept in mind that the formation and complete riveting of hydrates in subsea gas pipelines necessitates a complex and time-consuming process, such as the suspension and release of hydrates from the pipeline.

After suspension, the pipeline must first be emptied on both sides. Usually, at the beginning of the pipeline, there are no product losses due to the presence of a low-pressure gas collection system and a tank farm to discharge the pipeline. At the end of the discharged part of the pipeline, the release of gas into the atmosphere is inevitable due to the lack or limited availability of such facilities.

It was noted that the process that takes more time and causes more losses in the transport system is the melting of the hydrate. The process of hydrate decomposition is also delayed due to the fact that the water temperature is quite low on the seabed. Even in the relatively warm region - Caspian Sea, where subsea pipelines are laid at a depth of 50-100 meters, the water temperature is at 6^{o}C, so the decomposition of hydrate is weak due to poor heat exchange. For such cases, the use of special methods of influence are needed.

Observations in real subsea gas pipelines show that hydration and partial or complete blockage of the pipeline occur in two different scenarios.

The first case occurs more often at the end of the autumn season - the beginning of the winter season - when the temperature drops sharply. It is known that at this time of year there is no large free water-condensate accumulation inside the gas pipeline. Indeed, the relatively high temperature of the gas entering the pipeline during the previous summer season, due to the long-term high (30-40^{o}C) ambient temperature and heating during the movement of that gas in the pipelines, stimulates the recondensation of fluid accumulated in the pipeline during the previous winter-spring season. The obvious confirmation of this process is that the difference between the measurements of gas volumes at the start and end points of gas pipelines is much less than the average annual figure in the summer months, while in winter it is 1.3-1.5 times higher than normal.

The situation described above indicates that the movement of wet gas in the specified time interval (November-January) characterizes the formation and development of the process of precipitation (obliteration) of gas hydrate on the inner surface of the gas pipeline.

The second scenario of hydration and partial or complete blockage of the pipeline in real offshore gas pipelines is more common at the end of the winter season - the beginning of the spring season. This can be explained by the fact that large amounts of free water and condensate accumulate inside the gas pipeline as a result of the phase transformations that take place during the last winter season. A structure with a higher density than gas, consisting of water is formed from condensate and mechanical sediments (solid products from the reservoir falling into the pipeline due to corrosion of the inner wall of the tubing and imperfect separation) that accumulate in the lower parts of the subsea gas pipeline's descending and ascending profile (Bai, 2005: 66). Depending on the length of the pipeline and the profile of the seabed, this may occur in several places. For this reason, the cross-section of the pipeline decreases in the fluid-collecting sections of the pipeline, which characterizes the change in thermobaric conditions in the gas flow. A decrease in the cross-section of the pipeline results in an increase in the gas flow rate in that section and a decrease in the gas temperature due to post-section expansion (Vajari, 2012: 66). Lowering the temperature of the gas below the dew point temperature also ensures the formation of hydrate. In these cases, the difference between the volumes of gas measured at the start and end points of the gas pipelines exceeds the average annual figure. Thus, the increase in the difference between the measurements of gas volumes at stable pressures at the start and end points of gas pipelines can be used as a factor in the onset of the hydration process.

A number of methods are used to determine the location of hydrate formation:

- It is determined by installing a manometer in different parts of the pipeline and measuring the pressure by decreasing the pressure difference along the line;
- The fastest and cheapest way to locate hydrates or other sediments in a gas pipeline is the radar method. By installing antennas every 20-40 km along the gas pipeline and connecting them with a moving radar station, it is possible to determine the location of hydrate formation with an accuracy of a few meters (Makwashi, 2019: 6);
- A radioisotope device is also used to determine the location and thickness of the hydrate and the separated liquid. The block of the radiometric device is placed on the pipe and the place of hydrate formation is determined by the rapid drop of the device indicator;
- A radiodosing device (RIK-6M) is also used to locate hydrate-ice and liquid plugs. This device also works in the way that shown above.

It should be noted that the methods listed above are only suitable for onshore gas pipelines. It is impossible to apply these methods in subsea gas pipelines due to the lack of appropriate conditions.

For this reason, it is especially important to take preventive measures against the formation of hydrates and accumulation of liquid sediments in subsea gas pipelines. The most effective preventive measure is to release a cleaning device (piston) inside the pipeline with the approved schedule. When the ambient temperature drops sharply, the intensity of the piston release should be increased. In reality, it is not possible to release a treatment tool in all pipelines (old gas pipelines, any damaged ones, such as those damaged by the touch of the ship's anchor, etc.).

Unlike onshore gas pipelines, the number of technological parameters is very limited to accurately assess the moment of onset of hydrate formation in subsea offshore gas pipelines. Generally, no parameters other than the pressure at the beginning and end of the pipeline and the volume of gas injected into the pipeline are known.

When the ambient temperature drops sharply, the temperature of the gas supplied to the pipeline decreases, which increases the probability of hydration.

If methanol is injected into the pipeline in a normal mode with a certain specific consumption rate, in the new conditions there is a need to inject an increased amount of methanol into the pipeline.

Since hydrate formation and irreversible blockage occur in a short period of time (within 1-2 hours), determining the moment of onset of hydration to take prompt action can prevent serious losses. The following is an analytical method for determining the moment of onset of hydration in a subsea main gas pipeline.

Without taking into account the relief, the flowrate in the gas pipeline is Q, MCM/d is calculated with the following dependence:

$$Q = 3{,}32\cdot10^{-6}\cdot d^{2{,}5}\sqrt{\frac{P_b^2-P_e^2}{\lambda\Delta T_{ave}Z_{ave}}} \quad (1)$$

here: d – is the inner diameter of the pipe, mm;

P_b, P_e – Absolute pressures at the beginning and end of the gas pipeline, MPa, respectively;

Δ – relative density of gas to air;

T_{or} – average temperature of the transported gas on the gas pipeline, K;

Z_{or} – average compression coefficient along the pipeline, dimensionless;

L – length of the pipeline, km;

λ – hydraulic resistance coefficient of the gas pipeline, dimensionless.

We get the following by making certain transformations:

$$\frac{Q^2}{P_b^2-P_e^2} = \frac{11{,}0224}{\lambda\Delta T_{ave}Z_{ave}}10^{-12}d^5 \quad (2)$$

The known parameters on the left side of the equation are Q, P_b and P_e, on the right side there is a relative density Δ in the denominator, average temperature T_{ave}, average compression coefficient Z_{ave} and hydraulic resistance coefficient λ (Mogbolu, 2014: 59).

Let's examine the changes in the parameters mentioned before the point of hydrate formation after the moment of hydration formation.

There is a slight increase in Δ and Z_{ave}, which depends on the thermobaric (P, T) parameters, which do not change significantly due to a slight increase in pressure.

Since the gas temperature is formed at the source of the gas entering the pipeline (compressor station, gas preparation point), T_{ave} is partially reduced only due to heat exchange with the environment (sea water in the case of a subsea pipeline) (Bai, 2019: 110).

Results. Regardless of which factor is the first impulse of hydration - free water entering the pipeline or changes in thermobaric conditions (increase in pressure, decrease in temperature), the increase in viscosity due to the spread of «gas-water-hydrate» structures due to the formation of hydrate crystals results in a rapid increase in hydraulic resistance coefficient – λ.

In this case, the left side of the equation begins to decrease.

For this reason, the expression $K= \frac{Q^2}{P_b^2-P_e^2}$ can be used not only as a non-stationary function of flow, but also as an indicator of hydrate formation.

Normal dosing inhibition is performed to prevent hydrate formation. In case of complication, pressure (single 3-5 m3) inhibition is applied. If the latter does not work, the use of a wave-depression method as a last resort can prevent the pipeline from being completely blocked.

The essence of the wave-depression method is to increase the dynamics of the non-stationary mode by amplifying the wave processes in the gas flow in the pipeline by closing and opening the linear valve at the end of the pipeline, by taking advantage of special changes in thermobaric and gas-dynamic conditions due to gas compression.

Let's look at the sequence of processes.

1. As a result of closing the line valve at the end of the pipeline:

- The pressure begins to increase at the end of the pipeline;
- Gas continues to enter the pipeline (there may be a partial reduction);
- There is no increase in pressure at the beginning of the pipeline.

2. When an increase in pressure is observed at the beginning of the pipeline as a result of opening a linear valve at the end of the pipeline:

- Gas velocity increases sharply in the gas pipeline, especially in the sections near its end;
- Increased flow velocity forms different degrees of depression in different sections of the pipeline;
- Due to the greater depression in the narrower sections of the pipeline, the

liquid-hydrate compound, which usually forms in the lowest parts of the relief, is displaced and transported by the flow to the end of the pipeline.

To determine the shut-off time of the line valve at the end of the pipeline, let's determine the difference between the volumes of gas in the pipeline before and after the operation:

The volume of gas in the gas pipeline is determined by the formula $Vp = V \cdot \frac{P_{ave}}{P_0} \cdot \frac{T}{T_{ave}} \cdot \frac{1}{Z_{ave}}$, where $V = \frac{\pi D^2}{4}$ L - is the geometric volume of the pipeline.

The average pressure in the pipeline is determined by the formula $P_{ave} = \frac{2}{3}(P_b + \frac{P_e^2}{P_b+P_e})$ where P_b and P_e – are the pressures at the beginning and end of the pipeline, respectively, MPa.

Using the given expressions, we can determine the difference between the volumes of gas in the pipeline before and after the operation:

Using the given expressions, we can determine the difference between the volumes of gas in the pipeline before and after the operation:

$$\Delta V = V1 - V2 = \frac{\pi D^2}{6} L \frac{1}{P_0} \cdot \frac{T}{T_{ave}} \cdot \frac{1}{Z_{ave}} (P_b' - P_b + \frac{P_e'^2}{P_b'+P_e'} - \frac{P_e^2}{P_b+P_e}) \quad (3)$$

where P_b' və P_e' – are the pressures at the beginning and end of the pipeline, respectively, at the moment of opening the linear valve at the end of the pipeline, MPa; P_b və P_e – are the pressures at the beginning and end of the pipeline, respectively, at the moment of closing the linear valve at the end of the pipeline, MPa (Max, 2011: 22).

Discussion. Let's demonstrate the considerations with calculations for the real object, 65 km long, 500 mm diameter Oil Rocks-Bahar subsea main gas pipeline (Table 1).

Table 1

Re-gi-me	P_b	P_b^2	P_e	P_e^2	P_b-P_e	$P_b^2 - P_e^2$	Q	Q^2	$\frac{Q^2}{P_b^2 - P_e^2}$	Explanation of the situation, required technological actions
1	2	3	4	5	6=(2-4)	7=(3-5)	8	9	10=(9:7)	11
1	5.22	27.29	2.7	7.29	2.52	20	5	25	1.25	Simple, normal mode
2	5.5	30.25	2.7	7.29	2.85	22.96	5.36	28.73	1.25	Normal mode, just increased productivity
3	5.3	28.09	2.7	7.29	2.6	20.8	5	25	1.20	Attention. Record parameters every hour
4	5.4	29.16	2.6	6.76	2.8	22.4	5	25	1.12	Hydrate formation begins, take action, increase the inhibitor

5	5.5	30.25	2.5	6.25	3.0	24.0	5	25	1.04	Hydrate formation is intensified, pump the inhibitor with the emergency rate
6	5.6	31.36	2.4	5.76	3.2	25.6	4.8	23.04	0.9	A strong hydrate is formed, the pipeline can be fully blocked, switch to mode adjustment
7	5.6	31.36	2.3	5.29	3.3	26.07	4.5	20.25	0.78	The full blockage of the pipeline is approaching, switch to the spare pipeline (if any)

As can be seen from the table, the formation of hydrate is characterized by an increase in pressure at the beginning of the pipeline and a decrease at the end. However, the increase in pressure at the beginning of the pipeline may not be due to hydrate formation. For example, in certain cases (regime 2), since the increase in initial pressure and, accordingly, the pressure difference is associated with an increase in productivity, this is a normal regime and there is no risk of hydrate formation.

It should be noted that due to changes in the volume of gas extracted from the fields over time, as well as the formation of different intermediate pressures in the gas transportation system of the region, the values of the parameters given in Table 1 are relative and for demonstration purposes.

In this regard, in order to create a flexible control system against hydrate formation, hydraulic monitoring for each pipeline must be carried out for a certain period of time by the engineering and technical staff operating the subsea gas pipeline. As a result of monitoring, the boundaries of hydration regimes and the explanation of the situation and the required technological actions should be determined for each regime.

In order to simplify and speed up the work of the staff (operator) who directly control the modes of the gas pipeline, it is possible to create conditions for calculating and graphically observing the modes on the operator's computer using Excel (Balakin, 2010: 122). The operator will be able to immediately assess the situation based on the value of the expression $K=\frac{Q^2}{P_b^2-P_e^2}$ obtained after entering only 3 parameters (Q, P_b and P_e).

This method has been used for several years to predict the onset of hydration in the Oil Rocks-Bahar subsea offshore gas pipeline with real conditions, length 65 km, diameter 500 mm, initial pressure 5.5 MPa, final pressure 2.5-3.0 MPa.

This has repeatedly prevented the complete formation of hydrats, especially in the event of a sharp drop in ambient temperature.

Let's demonstrate the wave-depression method with calculations for the mentioned subsea main gas pipeline.

In the 7th mode in Table 1, find the volume difference due to the absolute pressures at the beginning P'_b =5,7 MPa, at the end P'_e =4,0 MPa (assume the values of other parameters P_0 = 0,1 MPa, T_{ave} = T = 273 K, Z_{ave}= 0,9):

$$\Delta V = \frac{\pi \cdot 0{,}5^2}{6} \cdot 65000 \cdot \frac{1}{0{,}1} \cdot \frac{273}{273} \cdot \frac{1}{0{,}9} \cdot (5{,}7-5{,}6+\frac{4^2}{5{,}7+4} - \frac{2{,}3^2}{5{,}6+2{,}3}) =$$

$$= \frac{3{,}14 \cdot 0{,}25 \cdot 65000}{6 \cdot 0{,}1 \cdot 0{,}9} \cdot (0{,}1+\frac{16}{9{,}7} - \frac{5{,}29}{7{,}9}) = 94491 \cdot (0{,}1+1{,}65-0{,}67) =$$

$$= 94491 \cdot 1{,}08 = 102050 \text{ m}^3.$$

Taking into account that in the 7th mode the gas enters the pipeline with the flow rate of 4.3 million m^3 / day, let's calculate the flow rate per minute:

$$q = \frac{4{,}3 \cdot 10^6}{24 \cdot 60} = 2986 \text{ m}^3/\text{min} \qquad (4)$$

Thus, we set the time for the valve to remain closed $t = \frac{\Delta V}{q} = \frac{102050}{2986} = 34$ minutes.

In general, using formulas (1) and (2), we can write the formula for determining the time when the valve is closed during operation as follows:

$$t = 240\pi D^2 qL \frac{1}{P_0} \cdot \frac{T}{T_{ave}} \cdot \frac{1}{Z_{ave}} (P'_b - P_b + \frac{P'^2_e}{P'_b+P'_e} - \frac{P_e^2}{P_b+P_e})$$

where q is the flow rate of gas entering the pipeline, Mm^3 / day.

We can determine the average pressures formed in the pipeline during the operation and the place where the average pressure is established in the pipeline:

$$P_{ave} = \frac{2}{3} (P_b + \frac{P_e^2}{P_b+P_e}) = \frac{2}{3} (5{,}6+ \frac{2{,}3^2}{5{,}6+2{,}3}) = 4{,}18 \text{ MPa}$$

$$P'_{ave} = \frac{2}{3} (P'_b + \frac{P'^2_e}{P'_b+ +P'_e}) = \frac{2}{3} (5{,}7+ \frac{4{,}0^2}{5{,}6+4{,}0}) = 4{,}91 \text{ MPa}.$$

Given that the square of the pressure along the gas pipeline varies in a straight line, we use geometric similarity to determine where the average pressure in the pipeline is established.

1. When the valve is closed at the end of the gas pipeline:

$$X = \frac{P_b^2 - P_e^2}{P_b^2 - P_{ave}^2} \cdot L = \frac{5{,}6^2 - 4{,}18^2}{5{,}6^2 - 2{,}3^2} \cdot 65 = 0{,}533 \cdot 65 = 34{,}645 \text{ km}$$

2.After the pressure increases at the end of the gas pipeline:

$$X' = \frac{P_b^2 - P_e'^2}{P_b^2 - P_{ave}'^2} \cdot L = \frac{5{,}7^2 - 4{,}91^2}{5{,}7^2 - 4^2} \cdot 65 = 0{,}508 \cdot 65 = 33{,}02 \text{ km}$$

3. The average pressure displacement in the pipeline is 34,645-33,02 = 1,625 km.

Thus, the place where the average pressure is established in the pipeline changes in the direction of the beginning of the pipeline at 1,625 km, which indicates that the thermobaric distribution has changed statically along the pipeline.

The proposed wave-depression method has been used in a number of subsea offshore gas pipelines, and hydrate eliminations in the pipelines have been achieved with high efficiency in the operation carried out in the correct sequence (Skovoborg, 1993: 453).

Conclusion.

1. The analytical method for determining of hydration in the subsea gas pipeline and the wave-depression method of elimination of already formed hydrate have been proposed.
2. Reports for the real gas pipeline demonstrate the effectiveness and informativeness of the methods.
3. The proposed methods are characterized by simplicity, the possibility of operational implementation and ease of use by staff.

Information about authors:

Iskandarov Elman Xeyrulla oglu – Azerbaijan State Oil and Industry University, dean of Oil and Gas Production faculty, DScTech; *e.iskenderov62@mail.ru*, 0000-0002-4297-0641;

Baghirov Shahriyar Alovsat oglu – Azerbaijan State Oil and Industry University, doctorant, MSc; *shahriyar.baghirov@gmail.com*, 0000-0002-9582-0823.

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