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RESEARCH OF THE TECHNOLOGY FOR HYDRATE PREVENTION IN GAS TRANSPORTATION SYSTEM

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Abstract

The principal aim of natural and associated gas preparation to transportation is provision of normal transportation inside field niacin gas pipelines. Developed gas and gas condensate field, production of which consists of great amount of different aggressive admixtures and mineral salts, require efficient of natural gas for further transportation.

The results of aforesaid system phase state test investigation are given in the article. Its presently at water phase and salt composition.

A Principals physical and chemical factors of inhibitor composition under different proportion of components were determined under laboratory conditions. New inhibitor composition, was selected on the base of experimental investigation results there also was developed the technology of inhibitor application for gas field treatment.

Since the efficiency of gas storage and transportation processes depends on the compliance of these processes with the requirements of the related equipment and relevant technologies, the operating modes of gas lift lines and compressor stations should be regularly examined. There is no doubt that the efficiency of storage and transportation of natural and associated gas is ensured at a distributed level, provided that the technological equipment is reliable, durable and operates in accordance with the requirements. One of the most important issues is to improve the used technology to prevent hydrate formation in the process of production, storage and transportation of gas condensate in complex conditions. On the basis of scientific a research and field surveys there were developed new scientific a technical measure to increase the efficiency of the installation for preparation of gas.

Keywords: compressor, gas, condensate, inhibitor, separator, technological, methanol, environment, liquid, transportation.

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1. Introduction

Selection of modern technologies and development of new scientific-technical proposals in order to overcome the technological challenges that may arise in the process of production, storage-transportation of associated gas and natural gas are one of the current topical problems facing our oil-gas industry.

It should be noted that the production and preparation of gas for transportation and its delivery to the gas-lift system in the offshore gas condensate fields of «Azneft» PU (Azerbaijan) is carried out in challenging conditions. The gas pipelines transmitted to the gas-lift system pass through a complex relief area in sea conditions. In addition to gas, a liquid phase (water + condensate) is released on the inner surface of gas pipelines passing through complex terrain areas. As a result, the productivity of the pipelines decreases, the pressure increases in the system, the volume of gas delivered to the gas-lift wells reduces and their efficiency decreases. Moreover, hydrate formation is observed in the system. This, in turn, leads to large gas losses in the system, increase in the energy costs, and the cost of gas prepared for transportation and consumed in the gas-lift system.

Eliminating technological difficulties in the production, collection and unimpeded transportation of gases in the fields of «Azneft» PU (Azerbaijan) is one of the most important issues of the day. One of these difficulties is the separation of the liquid phase from the gas during the production of gas from gas condensate fields and transportation. As a result, the rhythmic mode of operation of gas pipelines is violated, its productivity decreases, and it increases energy costs consumed on transported gas. In order to overcome the technical and technological difficulties arising in the gas industry, it is required to construct equipment for drying gases in gas condensate fields and put it into operation. It is important to develop new high-efficiency technological processes and guidelines for the use of absorbents in the process of gas dehydration. Taking into account these, the technological mode of operation of the compressor station and gas transportation units of the OGPD named after N. Narimanov (Azerbaijan) was studied.

2. Materials and methods

The technology used for hydrate prevention at OGPDs should be improved in order to eliminate these problems in a timely manner and improve the quality index of gas delivered to the gas-lift system pipelines [1–5]. Carrying out these works will create conditions for stabilizing the consumption of the inhibitor used for hydrate prevention and efficient operation of gas-lift pipelines.

The gas transportation system was investigated at the OGPD named after N. Narimanov. It was found out that the preparation of gases for transportation in the gas-condensate field at the OGPD is carried out by the separation method. High-pressure gas produced from gas-condensate wells which are exploited in «8 Mart» field of the OGPD passes through a 1-stage separator, and in this case, a liquid mixture (water + condensate) is separated from the gas. A part of high pressure gas is supplied to the compressor less gas-lift wells and the other part enters the gas-storage station (g.s.s.). In this case, the liquid phase is separated from the gas once again. Initially, the purified gas enters the gas compressor shop with 16^{11} collectors. The diagram of gas storage-transportation system at the OGPD is presented in **Fig. 1**. In addition, low-pressure associated gases produced from oil fields are supplied to the storage station at 0.5–0.6 MPa. From there, the compression gas is supplied to the compressor inlet at the station passing through a separator and being purified from the liquid phase. At the compressor station, low-pressure gas is compressed through 3 steps and supplied to the separator at the compressor outlet. Here, additionally liquid is separated from the gas, the liquid mixture separated from the gas is collected in tanks, and the gas purified from the liquid phase enters the collector 12^{11}. The collector is divided into 3 lines, 2 of which are 10^{11} and 1 is 8^{11}. High-pressure compressed gas (6.9–7.0 MPa) is supplied to gas lift wells through these lines. The gas supplied to the gas-lift system cools due to seawater, and as a result, hydrate is formed in the system. The pressure of the gas supplied from the compressor to the gas-lift system is 6.3–6.6 MPa, 800–1000 m^3/day of compressed gas is supplied to the gas-lift system.

The efficiency of preparation of gases for transportation technology depends mainly on the following indicators:

– preparation of dew point of gases for water and hydrocarbon vapors in accordance with demand;

– correct selection of technological equipment;

– correct selection of glycols used in the process of gas dehydration;

– calculation of consumption norms of glycols used in the technological system.

In world practice, the process of removing moisture from gases by cooling through low-temperature separation units in gas and gas condensate fields is widely used. If reducing the gas pressure is necessary, the gas can be cooled by expansion, as well as by passing it through a refrigerating unit. In order to lower the temperature the process of expansion is possible in two ways – by throttling without any external influence (isoenthalpic process) or by adiabatic expansion with external influence (isoentrapic process). In such cases, if the gas pressure does not fully ensure the gas cooling process by expansion way, supplementary or substituting expandable refrigerating units are installed at the inlet of the low-temperature separation unit. The required separation temperature can be provided thanks to supplementary heat exchanger-recuperator and refrigerating units. Glycol is injected into raw gas stream before the heat exchanger to prevent hydrate formation.

Taking this into account, it is important to develop new complex absorbents and composite inhibitors for oil and gas industry.

3. Results and discussion

The results of mining research showed that one of the challenges generating in gas-condensate wells, collector and gas transportation facilities is the formation of hydrate in the system. The components of the gas combine with water to form hydrated compounds in the form of crystals.

Technical, thermodynamic indicators of the wells exploited in OGPD, physical and chemical properties of the produced product were determined and operating modes of offshore oil and gas collection station used for gas transportation were investigated.

Currently, gas condensate wells are being exploited in OGPD. Thermodynamic indicators of gas condensate wells in OGPD named after N. Narimanov are presented in **Table 1**.

Analysis of the technological and thermodynamic parameters of gas condensate wells exploited in OGPD showed that the gas production, pressure and temperature of the wells dropped significantly and the fields are in the final stage of development. Therefore, the increase in free formation water flowing with gas creates a number of technological difficulties in the gas transportation system.

At present, the compressor station (CS) is being exploited in OGPD.

The results of initial studies in OGPD showed that the temperature of the gas transported from OGPD to the shore and the gas lift system is rapidly falling due to seawater. As it is known, seawater temperature varies depending on the depth of the water and seasons. Since both underground and surface gas pipelines pass through different places, they are constantly in heat exchange with the environment in the system.

Table 1
Thermodynamic indicators of gas condensate wells exploited in OGPS No. 3 of OGPD named after N. Narimanov

Well No.	Pressure, MPa			Production, tons/day	
	center	pipe back	annular space (downcome)	oil	water
552	1.1–1.2	1.7	1.6	1	2
561	1.55	1.75	1.65	7	8
578	1.0–2.9	4.5–7.3	1.5–4.4	6	1
588	0.9	0.9	0.9	6	4
589			Being used intermittently		
646	0.7	0.7	0.7	0.1	–
652	3.0	2.2	–	10	2
693	1.6–1.8	1.8–2.0	1.6–1.8	9	8
704	1.2–1.3	1.2–1.3	1.2–1.3	5	6

The temperature regime of submarine gas pipelines differs from the temperature regime of underground gas pipelines in that the temperature regime at the water surface changes intensively. The gas pressure remaining experimentally constant in the pipelines, but the temperature changing intensively lead to emergence of technological difficulties (hydrate formation) in the system. The results of research and mining operations in OGPD named after N. Narimanov showed that the liquid phase separates (water + condensate + oil fractions + paraffin sediments, etc.) from the gas phase on the inner surface of the pipelines as a result of the changes in thermodynamic indicators (P, T, Q, etc.) in the process of transportation of natural and associated gases by pipelines, in addition, hydrate compounds are formed. This, in turn, creates technological difficulties in gas pipelines, reduces the productivity of gas pipelines, leads to large losses of gas and condensate, as well as creates an emergency situation in the system. Eliminating these difficulties requires additional maintenance and energy costs.

Besides, the operating mode of gas collection and transportation units located in the coastal area of OGPD named after N. Narimanov was investigated.

Currently, hydrate inhibitor-methanol is injected at the outlet of the separator to prevent the formation of hydrate in the gas transportation system at the OGPD named after N. Narimanov (**Fig. 1**). In the methanol inhibitor tank, it is injected into the gas stream with the calculated consumption rate per 1000 m^3 of gas through HD 25/100 brand dosing pump. At the same time, hydrate formation is observed in the high-pressure gas lines which is supplied to the gas lift system and coming out of the compressor station so that in order to prevent this, 0.5 kg of methanol is injected per 1000 m^3 of gas in addition to the gas stream at the outlet of the gas-lift line. This regime is valid from October 1 to April 1. As a result, unimpeded transportation of gas in the field is provided. While investigating the technology of methanol injection into the gas stream, the followings were discovered:

– the same technology is not used at the OGPD to prevent hydrate generating during gas transportation;

– methanol is injected into the system in the usual way, i.e., without applying any modern equipment.

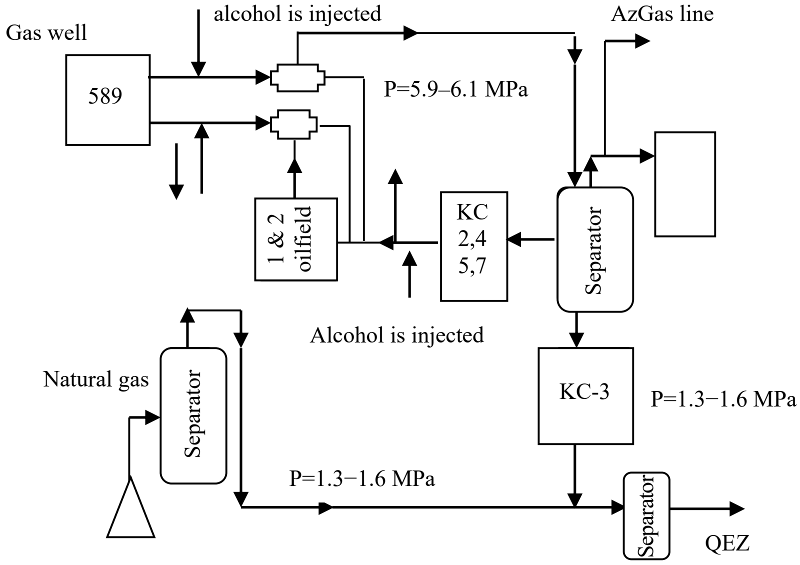

Fig. 1. Diagram of gas storage-transportation system at the OGPU named after N. Narimanov

The distance between the methanol injected into the gas stream and the separator is very small (3−4 meters), which in turn does not allow the methanol to be evenly distributed in the gas and liquid phases. The contact time between the methanol injected in the system and the gas phase is so short that the methanol is unevenly distributed in the gas-liquid phase and the bulk of the inhibitor passes into the liquid phase. As a result, the reliability of unimpeded gas transportation in the system reduces. The results of the conducted research show that the main source of challenges generating in the process of preparation of gas for transportation is the obsolete equipment used in the transportation process, and as a result, the quality indicators of transported gas does not meet the requirements. The diagram of methanol distribution at the OGPD gas condensate wells is presented in **Fig. 2**. One of the most important problems at the OGPU named after N. Narimanov is the improvement of technologies used to prevent hydrate formation in the process of production, storage-transportation of gas condensate in challenging conditions. In addition, drying of gas in water vapor by means of multifunctional inhibitors to increase the efficiency of production, storage-transportation of natural and associated gases is technically, technologically and economically efficient to prevent the formation of hydrate, corrosion, salt. Mining research is being conducted in recent years to study, analyze and improve the operation of technologies used in the oil-gas industry in order to reduce operating costs and the rate of consumption of the inhibitor injected into the system. Moreover, one of the most important problems of the oil-gas industry is the preparation of gas quality indicators in accordance with international requirements and ensuring unimpeded transportation of gases.

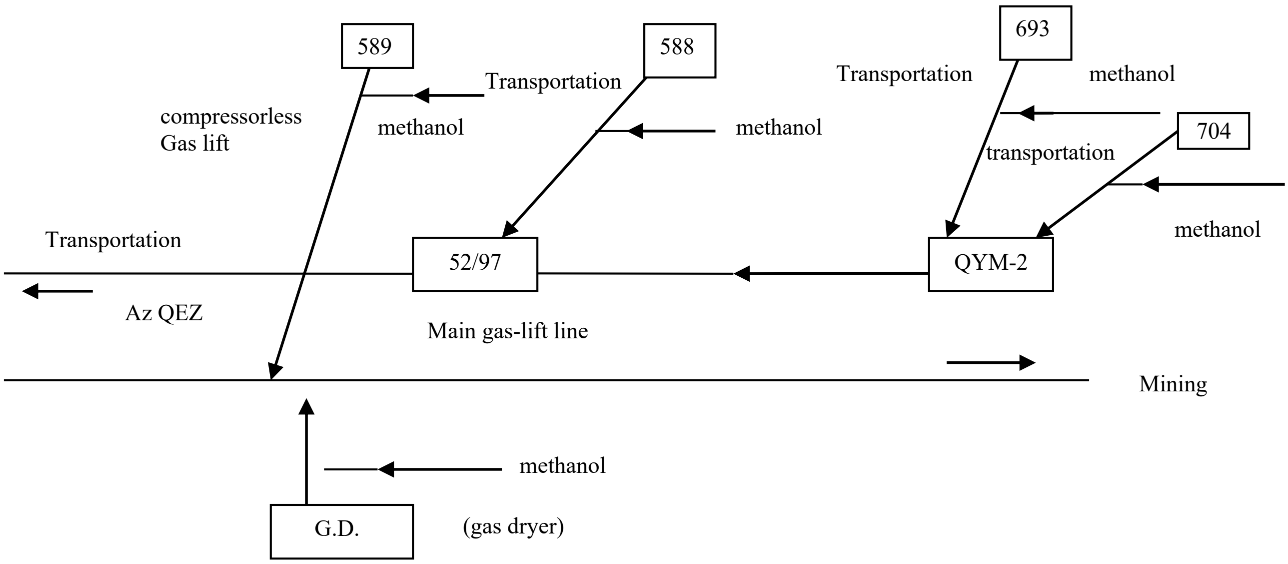

Fig. 2. The diagram of distribution of methanol from gas-condensate wells 588, 589, 693, 704 of OGPD named after N. Narimanov

At the OGPD named after N. Narimanov, the low-pressure associated gas separated from the oil according to the technology enters the liquid storage section of the separator, where the gas changes its direction several times as it passes through the internal partition. The gas releasing from the separator enters the compressor station. As a result of changes in temperature and pressure in the gas transportation system, a liquid phase (water+condensate) is released from the gas to the inner surface of the pipeline, which in turn creates technological challenges in the system. In order to prevent the mentioned challenges, it is expedient to use modern technologies to increase the efficiency of the gas-lift system in the fields of the OGPD. The main reason for the challenges is that the temperature of the transported gas decreases (4–5 °C) due to the gas pipelines passing through various relief areas and the impact of the environment, resulting in a liquid phase drops in the pipelines (water $++C_5+$), which reduces its cross-section and the system provides additional resistance to the unimpeded gas transportation process. As a result, hydrate compounds are formed in the gas-lift system at the OGPD.

It was revealed from the conducted research that hydrate formation is observed in the following places of the OGPD named after N. Narimanov:

a) when lowering the gas pressure where the nozzle is located;

b) in pipelines up to separators (mainly in areas with intensive heat exchange between gas and the environment);

c) in separators where gas pressure drop and temperature change are observed;

d) in diaphragms available in the measuring field;

d) in collector-gas pipelines connected to the common collector;

e) in the collectors for gas storage in the field.

In addition, the formation of hydrate compounds is observed at individual technological points of the gas transportation system at the OGPD.

When investigating the operation of gas-lift lines at the OGPD, it was found that the change in temperature regime in the pipelines depends mainly on three factors:

– the impact of environment temperature on the system during the motion of gas stream in the pipeline;

– drop in gas pressure (Coul-Thomson effect) and in gas temperature;

– changes in the temperature of gas stream as a result of the frictional force generated during the its motion inside the pipeline.

The temperature of gas pipelines is determined by the following formula [3]:

$$t - t_0 + (t_n - t_0)^{-e^{-ax}} - D\frac{p_1 - p_2}{\ell}\frac{1 - e^{-ax}}{\alpha} - \frac{A}{Cp}\frac{\Delta z}{\ell}\frac{1 - e^{-ax}}{a},$$

where $\alpha = K\pi D/\rho CpQ$, t and t_0 – gas temperature in the pipeline and in the environment, °C; t_n – initial gas temperature, °C; D – Coul – Thomson effect, °C/MPa; p_1 and p_2 – pressure at the beginning and end of the gas pipeline, MPa; l – the length of gas pipeline, meter; Cp – heat capacity of gas, KDG/kg; K – heat transfer coefficient of the environment, KDG/m^2 hour °C; D – diameter of the gas pipeline, m; ρ – gas density, kg/m^3; Q – gas consumption, m^3/day; x – distance from the beginning of the gas pipeline to the report area, m; A – the points determined at the beginning and end of the gas pipeline; Δz – the points determined at the beginning (z_b) and end (z_s) of the gas pipeline:

$$(z = z_s – z_b), \text{ m.}$$

If the gas pressure changes in the process system insignificantly, then the change in temperature in the pipelines is calculated using the following formula:

$$t = t_0 + (t_n - t_0) - \ell^{ax}.$$

Using the proposed formula, it is possible to pre-calculate the volume of the liquid phase dropping in the gas-lift line as a result of temperature changes in the system. This, in turn, allows the development of new scientific-technical proposals to increase the efficiency of gas-lift lines and prevent future complications in the technological system. Overcoming the difficulties mentioned above can be implemented through an efficient storage system in the fields, associated gas collection and the use of modern technologies.

It should be noted that in order to increase the efficiency of removing liquid mixture falling in low pressure gas pipelines, it is expedient to apply reagents created on the basis of local chemicals or pistons containing gel created on the basis of various chemicals to the high-pressure gas stream supplied to the line. It will allow the motion of balloons and pistons containing gel, which will be used to remove the liquid phase falling on the inner surface of the high-pressure gas pipeline supplied to the system. This, in turn, intensifies the removal of the liquid phase from the gas-lift system and will prevent gas losses in the system.

The proposed method is simple and the works mentioned above can be carried out by making some changes in the technology of mining equipment.

The results of the mining research showed that in previous years, a balloon was released to each line in order to increase the efficiency of the gas lines in the gas-lift system and purify the liquid phase (water + condensate) falling in the line. The release of the balloon was not so effective. In order to ensure the efficient operation of the «balloons» to be used in the process of cleaning the gas lines from the liquid phase and other mixtures, it is more expedient to inject reagents that create a foam system inside. In addition to the above-mentioned methods, the use of high-viscosity elastic compounds is very effective in cleaning gas pipelines from collections of various composition.

Since the efficiency of gas storage-transportation processes depends on the compliance of these processes with the requirements of the equipment and relevant technologies, the operating modes of gas-lift lines and compressor stations should be regularly investigated. There is no doubt that the efficiency of storage-transportation of natural and associated gas is ensured at a distributed level, provided that the technological equipment is reliable, stable and operates in accordance with certain requirements.

Productivity of gas-lift lines for gas, rhythmic processing of each line, important factors impacting on its starting and ending points and the compressor station, i.e. increasing or decreasing its productivity, were determined.

According to the results of scientific research, a new inhibitor composition was developed on the basis of local products to replace the toxic methanol used to prevent hydrate compounds generated in the gas lift system [6–10]. The advantage of the composition is that it is environmentally friendly and economically efficient.

The main objective is to realize the measures developed based on the results of the research conducted, provide the quality indicators of the gas prepared for transportation according to the demands. For this purpose, the development of a new composite inhibitor in the preparation of gases for transportation and the results obtained in its exploitation have been investigated and the obtained results have been analyzed. These newly applied inhibitors are reported to be obtained on the base of local chemical products, and research has also determined that the cost of the new product is low and the quality is high.

4. Conclusions

According to the results of the research and analysis conducted by the OGPD named after N. Narimanov, the following scientific-technical proposals have been developed to ensure unimpeded transportation of gases:

– purification of gas supplied to the gas-lift system, drying it from hydrocarbons and water vapor;

– construction of a gas dryer at the OGPD to prevent hydrate formation in the gas-lift system;

– improvement of internal elements of the separator exploited at the OGPD;

– use of new effective pistons containing gel to increase the efficiency of the process of cleaning gas lines from liquid mixture;

– creation of foam reagents of various composition and delivery to the gas line;

– use of a newly created composition inhibitor to increase the efficiency of the gas transportation system at the OGPD;

– selection of the technology to ensure even distribution of the inhibitor injected into the gas stream in phases;

– provision of the technology of injecting the inhibitor in aerosol form;

– reduction of methanol consumption used against hydrate compounds formed in OGPD gas-lift lines.

Based on the results of the research work, the increase in the efficiency of gas transportation technology and gas-lift system will be achieved by implementing scientific-technical proposals developed to improve the technology used for hydrate prevention in the transportation system at OGPD.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Manuscript has no associated data.

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