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STUDY OF THE TECHNOLOGICAL OPERATING MODE OF EQUIPMENT USED IN OIL AND GAS PRODUCTION

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A B S T R A C T

Eliminating the technological difficulties encountered in the extraction, collection and transportation of gases through pipelines is one of the most urgent issues . The fact that the pressure of the gas in the pipelines remains practically stable, but the temperature changes intensively, creates technological difficulties in the system. In order to overcome these technological difficulties in the gas transportation system, the gas must be conditioned to meet required quality specifications to separate the liquid phase from gas streams, restore the steady operation of pipelines, and increase productivity. Taking these into account, the technological operating mode of the compressor station and individual units of gas-preparation facilities for transportation were studied. For this, in the process of drying gases, glycols are widely used. In order to increase the efficiency of gas preparation technology for transportation, absorbent polypropylene glycol, which has better properties than traditional inhibitors and is used in the process of gas drying, was prepared on the basis of local chemical products, using this inhibitor polypropylene glycol and this allows to obtain higher results. The technological mode of operation of individual units of gas-preparation facilities for transportation has been studied. Innovations were made to the technological scheme of the gas drying unit and an increase in efficiency was achieved. The absorbent is passed through mechanical and carbon filters to be cleaned of impurities and is fed to the regeneration unit through the pump. At the same time, the regeneration of this inhibitor takes place at a low temperature, i.e. 150–160 °C, which is economically profitable and used in production.

Keywords: gas; compressor; transport; equipment; thermobaric conditions; absorbent; moisture; separator.

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1. Introduction

Extraction of gas, its collection, and the uninterrupted transportation through pipelines pose significant technological challenges at the Azneft Production Union (Azneft PU). One of the key challenges involves extracting gas from gas condensate reservoirs and separating it from the liquid phase during transportation. This leads to disruptions in the rhythmic operation of gas pipelines, resulting in decreased productivity and increased energy consumption for the transported gas.

To address these technical challenges in the gas industry, it is essential to focus on constructing and utilizing equipment for drying gas in gas condensate reservoirs. The use of new, highly efficient technological processes, particularly the application of absorbents in the gas drying process, is crucial. Excess water vapors, liquid hydrocarbons, harmful components and mechanical impurities contained in the gas prepared for transportation in the OGPD reduce the productivity of gas pipelines, increase the consumption of inhibitors, and corrode gas field equipment. This makes it difficult to transport gas without obstacles. In order to eliminate these technological difficulties in the gas transportation system in time, it is required to prepare and transport its quality indicators in accordance with the demand [1-4]. One of the main factors of ensuring the smooth transportation of gas is the preparation of its quality indicators in accordance with the demand.

Taking these factors into account, a study has been conducted on the technological operation of the N. Narimanov Compression Station and the gas preparation units for transportation at the Oil and Gas Production Department (OGPD) named after N. Narimanov (hereafter N/OGPD).

2. Materials and methods

The thermodynamic indicators of gas (*P*, *T*, *Q*, etc.) vary depending on the exploitation period of Oil and Gas Production Facilities gas-condensate reservoirs, which, in turn, affects the integrity of the technological system. The technology and consumption of absorbents and inhibitors injected into the gas stream change accordingly. In the technology of preparing gas for transportation, it is essential to create economically viable, efficient, and environmentally friendly new compositions of absorbents – mainly absorbents and hydrate inhibitors [5-10].

In the process of drying gases, technical alcohols are widely applied on a large scale. Alcohols – ethylene, diethylene, triethylene glycols are colorless, transparent viscous liquids

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that mix with water in various proportions. The ability of their aqueous solutions (70–85 mass %) to freeze at lower temperatures allows them to be used as inhibitors in the process of preparing gas for transportation [9, 11-15].

The preparation of the quality indicators of the transported gas in accordance with the demand mainly depends on the operating mode of the technological facilities, the main gas pipeline, the climatic conditions of the region, the quality of the transported gas and the absorbent used in the technological process. The implementation of these works requires the improvement of existing facilities and the development of new technologies. One of the main quality indicators of the gas prepared for transportation is the amount of moisture in its content and the determination of the dew point temperature. In order to ensure that the quality indicators of the transported gas are prepared in accordance with the demand, it is necessary to initially determine the dew point temperature of the gas according to water vapors and hydrocarbons, the amount of sulfur compounds, mechanical mixtures and oxygen contained in it [16-18]. Due to the water vapors of the gas being transported, the temperature limit of the dew point should be several degrees lower than the temperature obtained as a result of gas cooling in the gas pipelines.

In practice, the method with 90–95 % absorption is used in the process of preparing the quality indicators of the gas extracted from gas and gas condensate fields for transportation according to the demand. The indicators of the gas absorption drying process mainly depend on the moisture absorption capacity, viscosity, and consumption rate of the selected absorbent. Development and application of new efficient absorbents to solve this problem is one of the most important problems of the oil and gas industry.

Glycols have a higher viscosity, are less toxic, and have a higher boiling temperature compared to methanol. Their density is 1110–1115 kg/m^3. Therefore, the losses of glycols due to mechanical reasons in the process of preparing gases for transportation are 3–5 times less than that of methanol.

The cost-effectiveness of the gas preparation technology depends mainly on the following procedures:

– adequate preparation of the gas dew point temperature for water and hydrocarbon dew points;

– proper selection of technological equipment;

– proper selection of alcohols used in the process of gas drying;

– calculation of the consumption standards for the alcohols used in the technological system.

3. Results and discussion

The exploration and exploitation of natural and associated gases in the extraction, collection, and preparation process at Azneft PU's N/OGPD are of great importance for researching and improving the technological operating mode of the equipment used. The gathering and analysis of indicators hold significant value for enhancing the efficiency of the gas preparation technology.

Field data about the untapped reserves in OGPD has been collected and analyzed. Currently, there are two oil and gas condensate fields in operation under N. Narimanov OGPD.

The technical and thermodynamic parameters of the wells in operation at OGPD, as well as the physical and chemical properties of the extracted products, have been determined. Additionally, the operating modes of the offshore oil and gas gathering facility used for gas preparation have been investigated. Currently, gas condensate wells are in operation at OGPD. The thermodynamic parameters of the gas condensate wells in N/OGPD and the "Bulla-Deniz" reservoir are provided in tables 1, 2.

The analysis of technological and thermodynamic parameters of gas condensate wells exploited in OGPD revealed that the production, pressure, and temperature of the wells have significantly decreased due to the final stage of reservoir processing. Consequently, the increase in free water production with gas poses several technological challenges in the gas transportation system [19, 20].

Currently, a gas compressor station (GCS) is utilized in OGPD. Initial research results in OGPD indicate that the temperature of the gas transported from OGPD to the shore and gas lift system drops rapidly, influenced by the temperature of seawater. It is known that the temperature of seawater varies depending on the depth of the water and the seasons. As both underground and surface gas pipelines pass through different locations, there is a continuous heat exchange with the surrounding environment. The temperature regime of underwater gas pipelines differs from that of underground gas pipelines, as the temperature regime on the water surface undergoes intensive changes.

The experimental observation of maintaining constant pressure but experiencing intensive temperature changes in pipelines leads to technological challenges, such as

Table 1
Thermodynamic parameters of exploited gas condensate wells at OGPF-3 (oil and gas production field) of OGPD

Wells №	Pressure, MPa			Production	
	Center	Wellhead	Annular space	Gas, thous. m^3/day	Condensate, t/day
552	1.1/1.2	1.7	1.6	46	4
561	1.55	1.75	1.65	85	8
578	1.0/2.9	4.5/7.3	1.5/4.4	62	7
588	0.9	0.9	0.9	62	5
589	**Intermittently operated**				
646	0.7	0.7	0.7	16	–
652	3.0	2.2	–	140	4
693	1.6/1.8	1.8/2.0	1.6/1.8	121	8
704	1.2/1.3	1.2/1.3	1.2/1.3	70	7

the formation of hydrates. Research and field operations conducted at N/OGPD demonstrate that the change in thermodynamic indicators (*P, T, Q*, etc.) during the transportation process of natural and associated gases through pipelines results in the separation of gas phase from the internal surface of pipelines into a liquid phase (water + condensate + oil fractions + paraffin deposits, etc.) and the occurrence of hydrate formations. The absorbents used for drying gas from moisture with liquid sorbents in gas condensate fields are ethylene glycol, diethylene glycol, triethylene glycol, polypropylene glycol and others. In the process of drying gases, the formation of hydrate compounds is very unlikely, because the temperature of the dew point of the dried gas is minus 15–25 °C. Depending on the pressure and temperature, the amount of absorbent to be injected into the gas flow is determined based on the water vapors contained in the gas.

This, in turn, creates technological difficulties in gas pipelines, reduces the productivity of gas pipelines, and leads to significant losses of gas and condensate, as well as creating a hazardous situation in the system. Overcoming these challenges requires additional exploitation and energy costs.

Furthermore, the operating mode of gas accumulation and preparation facilities in the coastal area of N/OGPD has been investigated. The technological scheme of the gas accumulation, transportation and distribution system is presented in figure 1.

Considering these issues, the construction and commissioning of a new gas dehydrator in OGPD have been proposed to prepare the quality indicators of the gas supplied from the GCS to the transportation system in accordance with the requirements. To overcome these challenges, in 2009, a gas dehydrator unit was constructed and commissioned at the output of OGPD's Compressor Station № 2.

The technological scheme of the gas dehydrator is shown in figure 2. Low-pressure associated gas comes from the 1st and 2nd gas lift well fields. Under a pressure of 0.4–0.5 MPa, at a temperature of 170 °C, it passes through the separator at a rate of 40–50 thousand m^3/h and enters the GCS. In the GCS, associated gas is compressed in two stages: in the 1st stage, the gas is compressed at a pressure of 1.6–2.0 MPa and its temperature is increased to 105 °C, then it passes through the cooler; in the 2nd stage, the gas is again compressed at a pressure of 2.5–3.0 MPa and its temperature is increased to 110°C, then it passes through the cooler. Then, the gas is delivered to the separator in the 1st stage, where water, oil droplets, and other impurities are separated from the gas. For dehydration of the gas from the separator, it is supplied to the dehydrator at a pressure of 2.5–3.0 MPa and a temperature of 30–35 °C. Currently, polypropylene glycol is used as an absorbent in the gas dehydrator at OGPD. The upper part of the dehydrator is supplied with absorbent, and the lower part is supplied with gas. When polypropylene glycol passes over the coils inside the gas dehydrator, it absorbs water vapor. The saturated absorbent passes from the dehydrator to the heat exchanger, where it meets with the regenerated absorbent and collects heat after the heat exchange. The absorbent is then sent to the regenerator block through mechanical and coal filters via a pump to be purified from impurities. The saturated absorbent is heated to 150–160 °C by electric heaters and regenerated. The regenerated absorbent is fed to the absorber through a dosing pump and the process is repeated in a closed system.

The quality indicators of compressed and transported gas from Compressor Station № 2 in operation at N/OGPD have been investigated. The results of the technological process

Table 2
Thermodynamic parameters of gas condensate wells operated in the Bulla-Deniz deposit at N/OGPD

Wells №	Pressure, MPa			Production	
	Center	Wellhead	Annular space	Gas, thous. m^3/day	Condensate, t/day
29	The connection is used periodically			5.5	-
30	"-"	"-"	"-"	4.8	-
42	"-"	"-"	"-"	5.7	1
46	"-"	"-"	"-"	4	-
53	0.9	1.9	2.0	22	1
60	1.5	2.8	1.6	52	5
66	1.8	1.8	2.0	33	-
73	Used for continuous operation			4	-
108	14.5	1.6	1.6	57	4
110	1.5	1.8	–	39	3

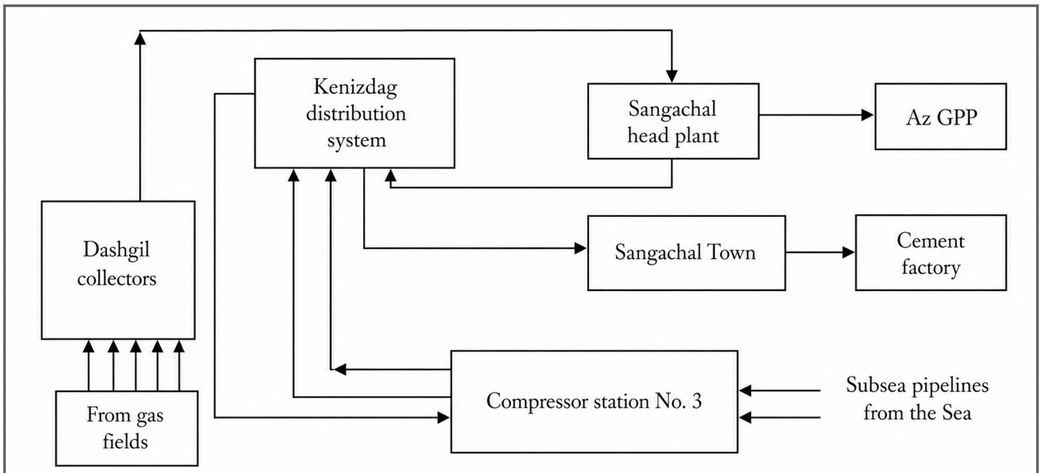

Fig. 1. Gas accumulation and transportation schemes in the coastal area of N/OGPD. Az GPP – Azerbaijan Gas Processing Plant

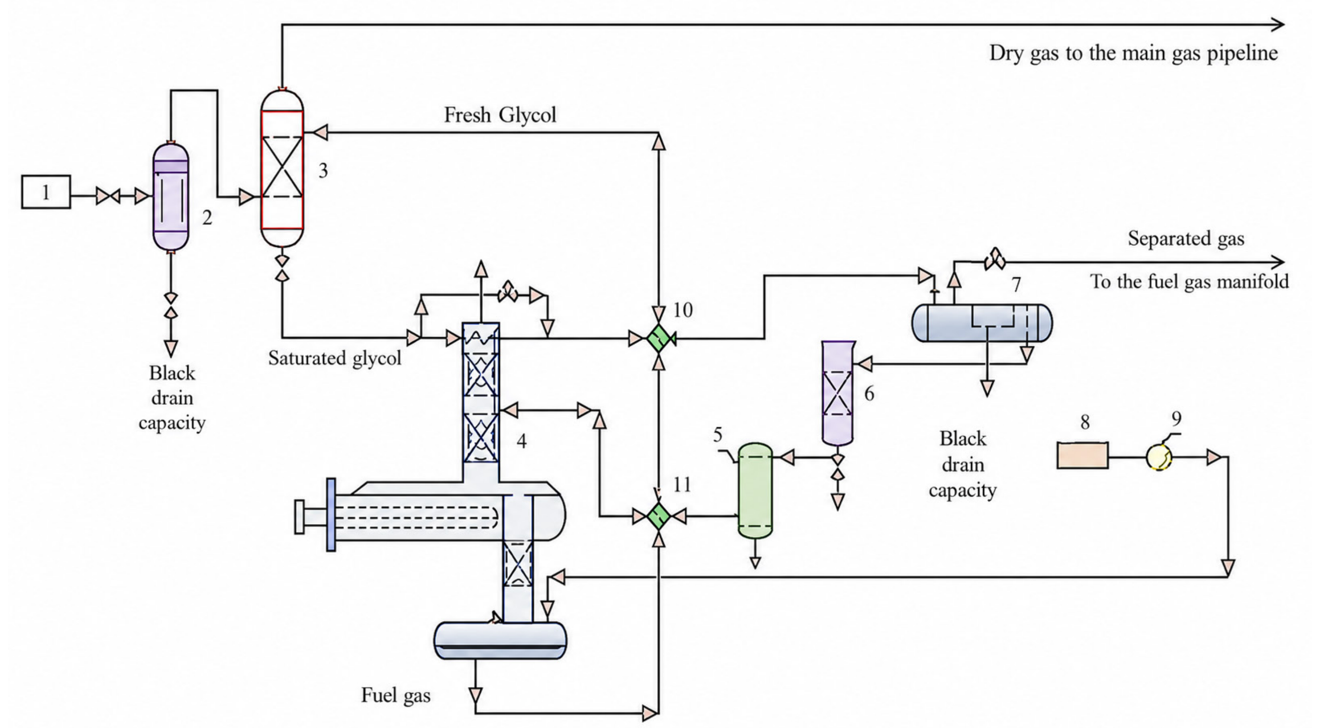

Fig. 2. Technological scheme of the gas collection and transportation system
1 – compressor station; 2 – separator; 3 – absorber; 4 – glycol regeneration block; 5 – mechanical filter; 6 – charcoal filter; 7 – capacity for fresh glycol; 8 – capacity for saturated glycol; 9 – pump; 10, 11– heat exchange facilities

research of the gas preparation units individually revealed that the quality indicators of the gas supplied from the output of the GCS to the transportation system do not meet the requirements (due to the temperature of the dew point for gas hydrates), and the occurrence of hydrate formations in the gas transportation system is observed. In order to prevent hydrate formation in gas pipelines and ensure the smooth process of gas transportation, an inhibitor – methanol is injected into the gas flow. Since there is no dehydrator to regenerate the methanol, it is exposed to complete loss, causing environmental pollution.

It should be noted that the temperature of the dew point for dry gas is – 5 to – 7 °C, and it is supplied to the transportation pipeline at a pressure of 2.4 MPa.

The absorbent used in the gas dehydration process is prepared based on local chemical products. The reserve amount of absorbent in the gas dehydrator is 5 tons. In the technological system, the loss of polypropylene glycol for 1000 m^3 of gas is 50 grams.

It should be noted that the drying of gas must meet the requirements in terms of quality indicators. Therefore, systematic control over the technological regime of the dehydrator and the physico-chemical indicators of polypropylene glycol used for gas drying must be maintained. Daily records should include the pressure, temperature, and the amount of gas entering the dehydrator. Nevertheless, samples of regenerated and water-saturated polypropylene glycol are taken from the dehydrator at least three times a day, and its basic physico-chemical indicators (density, viscosity, environment-pH, water content, etc.) should be determined in the laboratory.

It should be emphasized that the quality indicators of the gas prepared for transportation (temperature of the dew point) depend on the selection of the technological parameters of the dehydrator. The productivity of the dehydrator for gas is 700 000 m^3 per day, and it is 29–30 000 m^3 per hour. In the first half of 2023, 115 mln m^3 of gas was prepared for transportation using the absorbent. No difficulties were observed in the technological system during the period of using the absorbent in the gas dehydrator at OGPD.

The analysis of the conducted field research operations showed that the daily amount of natural gas extracted at N/OGPD is 829 000 m^3, monthly – 24 870 000 m^3, the daily amount of associated gas extracted is 331000 m^3, monthly – 9 930 000 m^3, and the amount of extracted condensate is 57 tons per day, and monthly – 1700 tons. The low-pressure associated gas supplied to the GCS (Gas Compressor Station) in N/OGPD has a volume of 950 000 m^3/day, a pressure of 0.4 MPa, and a temperature of 170 °C.

Drying of gas by absorption method in the used drying unit is the main technological indicator of the gas prepared for transportation. Therefore, the gas drying process must be constantly monitored. In absorption plants, it is often not possible to fulfill the gas quality parameters according to the demand. There are many organizational, technical and objective reasons for this. Thus, it depends on the drop in gas pressure, the change in the gas+absorbent contact temperature (mainly in summer) and so on. Gas pressure is one of the main factors that determine the specific consumption of the absorbent injected into the absorber to dry the gas and its loss with the drying gas. It is known that as the pressure increases, the moisture content of the gas decreases. At the same time, the consumption of the absorbent used for gas drying will be reduced.

In the process of gas drying, its temperature is one of the main factors that determine the technical and economic indicators of the process. The lower the temperature of the gas, the less moisture it contains in equilibrium. The gas-absorbent contact temperature has a lower limit, because lower temperature (0–5 °C) increases the viscosity of the absorbent, which in turn worsens the gas-absorbent mass transfer, causes the gas dew point temperature to fail to meet the required specifications and makes circulation in the system difficult.

The analysis of the field research operations conducted revealed that overcoming the challenges in OGPD related to gas extraction and transportation processes is one of the most important issues for the O&G industry.

In order to overcome the difficulties in OGPD, scientific research work has been carried out in the direction of implementing the technological process and instructions for the use of gas dehydrators with the use of absorbents. The analysis of the conducted field research operations showed that the technological regime of the Compressor Station and gas preparation units in N/OGPD has been investigated, and the field data have been collected and analyzed for optimizing the gas preparation process.

Conclusions

To increase the efficiency of the technology for drying gases from water vapor through the method of gas absorption, research has been conducted in the "gas-glycol" direction with the aim of conducting the process at lower temperatures. Based on the results of the field research, the implementation of the following measures is recommended:

– continuous determination of the temperature of the dried gas at the dew point using modern "moisture measuring" devices to ensure the quality parameters of the transported gas meet the requirements;

– continuous monitoring of the consumption of regenerated glycols provided to the contactor for drying the gas;

– installation of an automated control system based on a complex program for monitoring the technological system.

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