ANALYSIS OF THE TECHNOLOGY FOR PREVENTION OF HYDRATION RISKS IN TRANSPORTATION PROCESS OF GAS BY PIPELINE

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Abstract

In the article, the solution of the issues of transportation of the produced product in the oil and gas extraction department occupies one of the main places. Pipelines belong to technological systems that represent fire-explosion dangerous objects with a complex structure capable of hydrate formation, erosion, ignition, explosion and environmental pollution. By reducing technological risks that may occur in underwater pipelines, it is possible to ensure technological and environmental safety at sea and protect marine bioresources. Risk analysis using statistical data can reveal the negative consequences of natural hazards and other external influences on the pipeline system.

Keywords: gas, hydrate, oil and gas extraction, pipelines, risk, hydrocarbon accumulation, gas condensate, paraffin, condensate

I. Introduction

Researches and field works should be carried out to improve the technological process and develop new scientific and technical proposals in order to reduce hydrate formation and other possible technological risks during the process of gathering and preparing gases produced from gas condensate deposits for transportation. These research works should be carried out in several directions [1,5]. It can be determined by studying the operation of separate devices of hydrocarbon gas collection and transport preparation units operating in the oil and gas extraction station. Reducing the risks of hydrate formation during exploitation in field conditions, choosing the optimal technological mode of operation for the collection and preparation of hydrocarbon gases for transportation and the selection of reagents with high efficiency during the process are important issues [2,4].

II. Research and analysis of results

It is known that both underground and surface gas pipelines are constantly exchanging heat with the environment. For this purpose, it is considered technically, technologically and economically efficient to develop, apply reagents in the technological process to reduce the risk of hydrate formation, drying of gas from water vapors, corrosion, salt and paraffin deposits in the gas hydrocarbon collection, preparation for transporting and transportation system. Taking these into account, it is appropriate to analyze and improve the technological processes applied in the oil and gas industry in recent years to reduce the operational costs incurred in the gas collection, preparation for transporting and transportation processes, prepare quality indicators in accordance with international standards, and to decrease the risks of hydrate formation that may occur.

Since the efficiency of low-pressure gas collection and transportation processes depends on the compliance of the equipment related to these processes with the requirements of relevant technologies, the operating modes of pipelines and compressor stations should be investigated.

The study of the influence of the low-pressure gas transportation pipelines on the indicators of the station until the reception of the compressor station is carried out on the following issues.

The indicators of the compressor station consist of its destination parameters. These parameters are related to the following factors:

- factors that have a positive or negative effect on the operation of the compressor units of the low-pressure gas pipelines before the station reception;
- factors that increase or decrease the gas permeability of low-pressure gas pipelines;
- ambient temperature and humidity affecting gas pipelines and compressors.

The main factors affecting the ability of low-pressure gas transmission pipelines to the compressor station reception: depend on the diameter of the pipeline, its length and the curves of the pipelines.

In order to study the gas permeability of the pipelines, the construction of each pipeline is determined, after recording its starting and ending points, important factors affecting the compressor station, increasing or decreasing its productivity are determined.

The construction of plugs and connecting devices installed at the beginning and end points of the pipeline and the opening and closing times cause changes in gas parameters (pressure, temperature, and quantity) and thus affect the indicators of the compressor station.

The results of the conducted research and field work showed that as a result of the change of thermodynamic parameters (P, T, Q, etc.) in the process of transporting natural and associated gases, the gas phase leaves the liquid phase (water + condensate + oil fractions + paraffin deposits, etc.) on the inner surface of the gas pipelines. This creates difficulties in its turn. Thus, the formation of hydrate in the system creates an emergency situation, in addition to reducing the productivity of gas pipelines, leading to the loss of large volumes of gas and condensate. Overcoming these difficulties requires additional operating and energy costs.

Taking these into account, it is appropriate to consider in advance and report the temperature regime of the area where the gas pipelines pass, depending on the season, in order to ensure the smooth transportation of low-pressure gases to the compressor station.

The results of the research and field works carried out in the DWF show that the development of new scientific and technical proposals to ensure the unimpeded transportation of low-pressure gases from deep sea foundations to the under-construction FCS (field compression stations) is one of the urgent issues of the day.

The results of the conducted field studies showed that in order to increase the efficiency of the gas lines between the DWF and clean the liquid phase (water + condensate) falling into the line, it is planned to release a ball in each line of the project. However, the results of field studies show that an additional force is needed to ensure the movement of the ball inside the pipeline.

It is known that since the pressure of the surrounding gases is too low, 0.15-0.20 MPa cannot ensure the internal movement of the ball in the pipeline and its cleaning from the liquid mixture. Taking these into account, it is more effective to increase the efficiency of low-pressure gas transportation by using a number of technologies, as low-pressure gas transportation lines pass through complex relief areas.

During the movement of the gas through the seabed pipes, the liquid contained in it separates and after a certain time passes, preventing the passage of the gas, it ensures the formation of hydrate. Although this problem has been tackled in various ways, its solution is still relevant. Let's look at finding the pressure needed to clean up liquid build-up and eliminate the risk of hydrate formation when transporting gas through a pipeline on the seabed. In the first option, let's look at the worst case, that is, when the pipes are completely filled with a liquid mixture.

If to assume that the fluid is incompressible, its equation of motion is as follows [3]

$$0\leq s\leq \frac{\ell}{2} \qquad m\frac{dv}{dt}=P\cdot f-2\pi R(\ell-s)\cdot\tau-\rho g s f\,\sin\phi \tag{1}$$

Here $\sin\phi=\frac{2H}{\ell}$, $m=\rho\pi R^2(\ell-s)$ is the mass of liquid; ρ - the density of the liquid; ℓ; R, f - the length of the pipe, the inner radius of the pipe, and the cross-sectional area, respectively, τ - the friction between the fluid and the inner surface of the pipe wall is the shear stress.

If to substitute the mass of liquid in expression (1), we get the following equation:

$$\rho\pi R^2(\ell-s)\frac{dv}{dt}=Pf-2\pi R(\ell-s)\tau-\rho g s f\,\sin\phi \tag{2}$$

The relationship between the frictional stress and the average speed can be found as follows:

$$\tau=\mu v \tag{3}$$

μ - is the resistance coefficient between the surface of the liquid and the pipe wall. If to consider equation (3) in expression (2) and simplify, we get:

$$\rho\pi R^2(\ell-s)\frac{dv}{ds}v=Pf-2\pi R(\ell-s)\mu v-\rho g s f\,\sin\phi \tag{4}$$

Since the speed in the first approximation is small, if to ignore the resistance force, we get the following equation from expression (4):

$$\rho\pi R^2(\ell-s)\frac{dv}{ds}v=Pf-\rho g s f\,\sin\phi \tag{5}$$

If to integrate the differential equation (5), we get:

$$P=\frac{\rho v^2}{2\,ln\,2}+\frac{\rho g\ell\,\sin\phi}{ln\,2}(ln\,2-\frac{1}{2}) \tag{6}$$

By expression (6), giving the value of v, it is possible to calculate the pressure needed to squeeze out half of the liquid collected in the pipeline.

In the second option, after the level of the liquid in the pipeline falls to the height H, the pressure required to raise it is found as follows.

The equation of motion of liquid in a pipe:

$$m\frac{dv}{ds}v=P\cdot f-\rho g f(H-s\,\sin\phi) \tag{7}$$

$$m=\rho f(\frac{\ell}{2}-s)$$

If to substitute the mass of the liquid in equation (7), we get it:

$$\rho f(\frac{\ell}{2}s)v\frac{dv}{ds}=Pf-\rho g f(H-s\,\sin\phi) \tag{8}$$

If to integrate the differential equation (8), we get

$$P=\frac{\rho v^2}{2\,ln\,2}+\rho g(H\,ln\,2+\frac{\ell}{4}\sin\phi-\frac{\ell}{2}ln\,2\,\sin\phi)\frac{1}{ln\,2} \tag{9}$$

Considering the equations (6) and (9), the parameters of the pipes, l =3000m; H=200m; R=0.15m; ϱ = 10^3 kg/m^3; Numerical reports were made at values of v= 0.5m/sec. The results of the reports show that the pressure required to remove the first half of the liquid collected in the pipe is P≅0.3ϱgH, and to remove the second half is P ≅ (0.7÷1)ϱgH, that is, for the considered case P_{max} ≅ (1.4÷2.0) MPa, it is possible to completely clean the liquid accumulated in the pipe.

Based on the results of field research, the working pressure required to compress and remove the liquid collected from the pipe passing through the bottom of the sea was determined by means

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of a mathematical report. In order to ensure unhindered transportation of low-pressure gases between deep water foundations, high pressure (P ≅ 8-10 MPa) supplied to the gas lift system in separate foundations is drawn from the gas lines and low-pressure gas (P=1.5-2.0 MPa) should be given to the line.

Initially, the following technological scheme (Fig. 1) is proposed to ensure unhindered transportation of low-pressure gases between DWFs:

According to the scheme, a gas line (1.5-2.0 MPa) is taken (3) in addition to the high-pressure gas pipelines (1) supplied to the gas lift system (10) from DWF and supplied to the low-pressure gas line (5). Due to the high-pressure gas generated in the system, the liquid phase falling on the pipe is compressed and removed and collected in the liquid tank (8) located on the base.

The proposed method is simple and can be performed by making some changes in the technology of the field equipment located in the foundations. Based on the results of the research and analysis of the low-pressure gas lines to be supplied from the deep-water foundations to the FCS, the following scientific and technical proposals have been developed to ensure the unhindered transportation of gases. The results of the research and mining works carried out in the DWF showed that it is possible to ensure the unhindered transportation of low-pressure and high-pressure gases from deep seabeds to FCS.

The proposed scheme for the transportation of low-pressure gases between DWFs (Fig. 1).

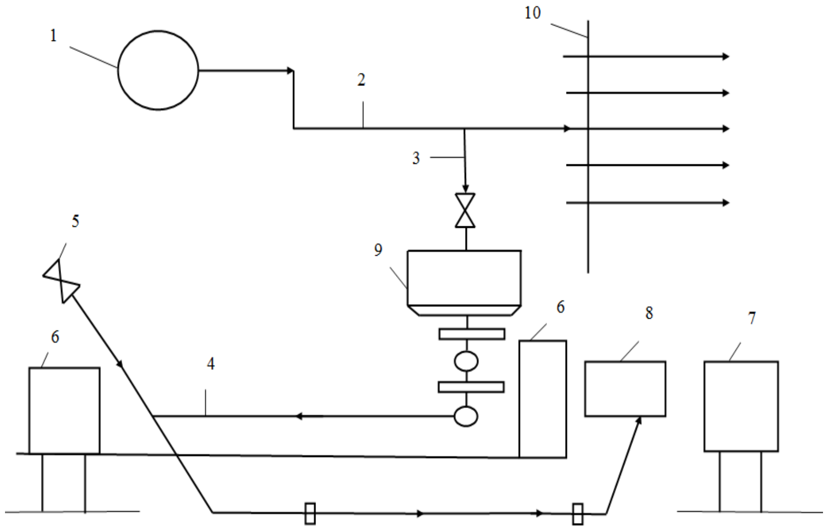

Figure 1: *1-high pressure gas condensate well; 2,3,4- high pressure gas line; 5- low pressure gas line; 6,7- DWFs; 8-liquid tank; 9- capacity for reagent; 10- gas line supplied to gas lift wells*

III. Conclusions

The purpose of reducing the risk of hydrate formation in the system of gathering, preparing for transporting and transportation of natural and associated gases is to find the rate of consumption of the reagent.

Improvement of the internal elements of the separators operated in each base where the waste gases are collected and installation of two and multi-stage separator devices in the technology.

Preparation and reporting of design documents for the construction of the separator and its internal elements.

The use of gel-containing pistons to remove the liquid falling in the low-pressure gas transport system.

Using mechanical pistons to clean the gas lines from the liquid mixture.

Creation of a foaming system based on foaming reagents of different composition and supply to the gas line.

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